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Standards of performance to control emissions of particulate matter from new, modified, and reconstructed calciners, dryers, and bleachers in natural process sodium carbonate plants are being proposed under Section 111 of the Clean Air Act. This document contains information on the sodium carbonate industry and emission control technology, a discussion of the selected emission limits and the supporting data and the alternatives which were considered, and analyses of the environmental and economic impacts of the proposed standards.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
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August 1980

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METRIC CONVERSION TABLE

In keeping with U.S. Environmental Protection Agency policy, metric units are used in this report. These units may be converted to common English units by using the following conversion factors:

Metric Unit	Metric Name	Equivalent English Unit
	LENGTH	
m	meter	39.3700 in.
m	meter	3.2810 ft.
	VOLUME	
l	liters	0.2642 U.S. gal.
m^3	cubic meters	264.2 U.S. gal.
	WEIGHT	
Kg	kilogram (10^3 grams)	2.2046 lb.
Mg	megagram (10^6 grams)	1.1023 tons
Gg	gigagram (10^9 grams)	1,102.3 tons
	ENERGY	
GJ	gigajoule	9.48×10^5 Btu
GJ	gigajoule	277.76 KWh
J/g	joule per gram	0.430 Btu/lb.
	VOLUMETRIC FLOW	
Nm^3/sec	normal cubic meters per second	2242 SCFM (ft^3/min)

Temperature in degrees Celcius (°C) can be converted to temperature in degrees Fahrenheit (°F) by the following formula:

$$(°F) = 1.8\ (°C) + 32$$

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1. SUMMARY

1.1 PROPOSED STANDARDS

New Source Performance Standards for particulate emissions from emission sources in the natural sodium carbonate industry are being proposed under the authority of Section 111 of the Clean Air Act. These standards will affect new, modified, or reconstructed calciners, dryers, predryers, and bleachers used in natural process sodium carbonate plants. There is no growth expected in the synthetic sodium carbonate industry, and therefore it will not be covered under the standards.

This Background Information Document provides the rationale and support for the proposed standards. The proposed standards, as stated in 40 CFR Part 60, Subpart II, are summarized in Table 1-1.

The required control of emissions can be achieved by the installation of particulate control equipment. Venturi scrubbers, alone or in series with a cyclone, and a combination of a cyclone with an electrostatic precipitator were demonstrated to be the best emission control systems. EPA source tests were conducted at three natural process sodium carbonate plants to demonstrate the particulate control capabilities of these control systems. Results of these tests are tabulated in Appendix C.

The analysis of the environmental and economic impacts of the proposed standards were based on the following control systems:

- calciner - cyclone/electrostatic precipitator
- rotary steam tube dryer - venturi scrubber
- fluid bed steam tube dryer - cyclone/venturi scrubber
- predryer - venturi scrubber
- bleacher - cyclone/electrostatic precipitator.

TABLE 1-1. SUMMARY OF THE PROPOSED STANDARDS FOR THE NATURAL SODIUM CARBONATE INDUSTRY

Emission Source	Proposed Standard	Opacity Standard
Calciners	0.11 kg/Mg dry feed (0.22 lb/ton)	5%
Dryers and predryers	0.045 kg/Mg dry product (0.09 lb/ton)	10%
Bleachers	0.03 kg/Mg dry feed (0.06 lb/ton)	5%

1.2 ENVIRONMENTAL IMPACT

The analysis of the environmental impact was based on two alternative regulatory options. These regulatory options were:

1. Control all facilities to the baseline control level.
2. Control all facilities to a more stringent control level (Proposed Standard).

Alternative 1 is equivalent to no regulatory action. Under this alternative emissions would be controlled to levels set by existing SIP regulations. The proposed standards are based on Alternative 2.

In 1985 the proposed standards will reduce emissions of particulate matter from new sources in natural process sodium carbonate plants by 55 percent over projected emissions under Alternative 1. This reduction in particulate emissions can be accomplished without causing any adverse primary or secondary environmental impacts.

Solid wastes generated by the dry collection systems are actually valuable material which is recycled to the process. Effluents from the wet collection systems also contain valuable product, and are recycled to the process. Thus, no water pollution or solid waste impacts result from the proposed standard. The water required to operate the wet scrubbers to meet the proposed standards is no more than that which would be used to meet existing state regulations.

The projected increase in electrical demand of the proposed standards over the baseline option is less than 1.4 percent of the total energy required to operate the natural process sodium carbonate plants (about 107 TJ/year).

A more detailed analysis of these environmental and energy impacts is presented in Chapter 7. A summary of the environmental and economic impacts associated with the proposed standards and the other options which were considered is presented in Table 1-2.

1.3 ECONOMIC IMPACT

Economic impacts under Alternative 2 would be minimal. Additional costs to comply with the Alternative 2 control levels would result in a maximum price increase for sodium carbonate of one percent. This increase could be passed on to sodium carbonate consumers without seriously affecting the industry. If the costs were to be absorbed by the producers, the resulting profit reduction would be unlikely to have a major impact on the producer's return on assets.

TABLE 1-2. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF REGULATORY ALTERNATIVES

Administrative Action	Air Impact	Water Impact	Solid Waste Impact	Energy Impact	Noise Impact	Economic Impact
Proposed Standards (Alternative II)	+3**	0	0	-1***	-1*	-1**
Alternative I (no standard, baseline)	0	0	0	0	0	0

KEY

+	Beneficial Impact
-	Adverse Impact
0	No Impact
1	Negligible Impact
2	Small Impact
3	Moderate Impact
4	Large Impact
*	Short-Term Impact
**	Long-Term Impact
***	Irreversible Impact

2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control based on different technologies and degrees of efficiency are expressed as regulatory alternatives. Each of these alternatives is studied by EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and the impacts on the environment. This document summarizes the information obtained through these studies so that interested persons will be able to see the information considered by EPA in the development of the proposed standard.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended, hereinafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission reduction achievable which (taking into consideration the cost of achieving such emission reduction, and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated for that category of sources." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources that have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

   a. 25 percent of the listed categories by August 7, 1980.
   b. 75 percent of the listed categories by August 7, 1981.
   c. 100 percent of the listed categories by August 7, 1982.

A governor of a State may apply to the Administrator to add a category not on the list or may apply to the Administrator to have a standard of performance revised.

2. EPA is required to review the standards of performance every 4 years and, if appropriate, revise them.

3. EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.

4. The term "standards of performance" is redefined, and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low- or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under Section 111 of the Act may be extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any non-air-quality health and environmental impacts, and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some states may attract industries by relaxing standards relative to other states. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term Best Available Control Technology (BACT), as defined in the Act, means

> ". . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from, or which results from, any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques

> for control of each such pollutant. In no event shall application of 'best available control technology' result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to Sections 111 or 112 of this Act. (Section 169(3))."

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, section 111(i) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require or an equivalent reduction at lower economic energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare, or safety; (4) the governor of the State where the source is located consents; and (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to three years to meet the standards with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgement it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants emitted by stationary sources. Source categories that emit these pollutants are evaluated and ranked by a process involving such factors as: (1) the level of emission control (if any) already required by State regulations, (2) estimated levels of control that might be required from standards of performance for the source category, (3) projections of growth and replacement of existing facilities for the source category, and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which new source performance standards were promulgated or under development during 1977, or earlier, were selected on these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all major source categories not yet listed by EPA. These are: (1) the quantity of air pollutant emissions that each such category will emit, or will be designed to emit; (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases it may not be feasible immediately to develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inablility to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from some of these facilities may vary from insignificant to very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, the non-air-quality health and environmental impacts, and the energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for developing standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard-setting process involves three principal phases of activity: (1) information gathering, (2) analysis of the information, and (3) development of the standard of performance.

During the information-gathering phase, industries are queried through a telephone survey, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from many other sources, and a literature search is conducted. From the knowledge acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several possibly applicable alternatives, EPA selects the single most plausible regulatory alternative as the basis for a standard of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard of performance, which, in turn, is written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the Background Information Document (BID). The BID, the standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standard is officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

As a part of the Federal Register announcement of the proposed regulation, the public is invited to participate in the standard-setting process. EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standard with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, D. C.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the "preamble" of a "promulgation package," which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance, (2) the potential inflationary or recessionary effects of the regulation, (3) the effects the regulation might have on small business with respect to competition, (4) the effects of the regulation on consumer costs, and (5) the effects of the regulation on energy use. Section 317 also requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and in terms of the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is necessary because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact from the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry. On this basis, therefore, the Court established a narrow exemption from NEPA for EPA determination under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793(c)(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by section 102(2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section in this document is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the general provisions of Subpart A of 40 CFR Part 60, which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under Section 111 (d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every four years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive, but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. THE SODIUM CARBONATE INDUSTRY

General information on the sodium carbonate industry is presented in Section 3.1. The facilities and their emissions are discussed in Section 3.2.

3.1 GENERAL

Section 3.1 is divided into two sections. Section 3.1.1 presents background information on the industry, and Section 3.1.2 presents descriptions of the processes used to produce sodium carbonate.

3.1.1 Industry Background

Sodium carbonate, or soda ash (Na_2CO_3), is a white, crystalline, hygroscopic powder. It is produced in different product density grades ranging from 560 kg/m^3 (35 lb/ft^3) to 1250 kg/m^3 (78 lb/ft^3) depending on the production process.

The major use for sodium carbonate is in the production of glass. Approximately 50 percent of the 7.3 million megagrams (8.0 million tons) of sodium carbonate produced in the U.S. in 1978 was used by the glass industry. Other major users of sodium carbonate and the approximate percentages of U.S. production accounted for by each in 1978 were the chemical industry (25%) and the pulp and paper, cleaning agents, and water treatment industries (16%). Nine percent of U.S. production in 1978 was exported.[1]

As of March 1979, there were eight sodium carbonate plants in the United States, with a total capacity of approximately 8.5 million megagrams per year (Mg/yr) or 9.4 million tons per year (TPY). The ownership, location, startup date, and capacity for each of these plants is presented in Table 3-1. The process used at each plant is also given.

TABLE 3-1. THE DOMESTIC SODIUM CARBONATE INDUSTRY

Owner	Plant Name	Location	Startup Date[a]	Capacity 10^6 Mg/yr	Capacity (TPY)	Process type	Employment
Kerr-McGee	Trona	Trona, CA	1978[d]	1.2	(1.3)	Direct carbonation	3600[c]
	West End	Trona, CA	f	0.14	(0.15)	Direct carbonation	
Allied Chem.	Trona	Green River, WY	1968	2.0	(2.2)	Monohydrate	
FMC Corp.	Westvaco	Green River, WY	1972	1.13	(1.25)	Monohydrate	
			1947	1.13	(1.25)	Sesquicarbonate	
Stauffer Chem.	Big Island	Green River, WY	1962	1.54	(1.65)	Monohydrate	
Texasgulf, Inc.		Green River, WY	1976	0.91	(1.0)	Monohydrate	
Allied Chem.		Syracuse, NY	1881	0.8	(0.9)	Solvay (synthetic)	1800[e]

[a] Startup dates are for the original plant unless otherwise stated. See Table 8-6 for expansion dates. Reference 2.

[b] Capacity data, with the exception of Kerr-McGee's Trona plant are valid through March, 1979. The value for Kerr-McGee's Trona Plant is a planned capacity for year-end 1979.

[c] Value includes employment for mine and plant. 1978 value. Reference 3.

[d] Kerr-McGee operated a small plant at this location prior to 1978. However, most of the reported capacity was added in 1978. Reference 3.

[e] Employment value is for the entire plant, which produces calcium chloride, chlorine, caustic soda, sodium nitrite, ammonium chloride, and sodium sesquicarbonate in addition to soda ash. 1978 value. Reference 4.

[f] Kerr-McGee purchased this plant from Stauffer Chemical Co. in 1974. Actual plant startup was not determined.

As indicated in Table 3-1, four different processes are currently used in the U.S. to produce sodium carbonate. Three of these processes, the monohydrate, the sesquicarbonate, and the direct carbonation are classified as natural processes. The fourth, the Solvay process, is classified as a synthetic process.

In the monohydrate and the sesquicarbonate processes, sodium carbonate is produced by processing naturally occurring deposits of trona ore (impure sodium sesquicarbonate, $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$). This ore is found in large deposits located near Green River, Wyoming.

The first plant to begin processing the trona deposits in Wyoming used the sesquicarbonate process. This plant was built in 1948, and it was subsequently expanded during the 1950's and 1960's. These expansions were the last additions to domestic capacity for producing sodium carbonate by the sesquicarbonate process. (The reasons that no increases in the production capacity to produce sodium carbonate by the sesquicarbonate process have since been made are discussed in Section 3.1.2.2.) Subsequent additions to all sodium carbonate production capacity in Wyoming have involved the construction or expansion of plants using the monohydrate process.

In the direct carbonation process sodium carbonate is produced from naturally occurring brine which contains sodium sesquicarbonate, sodium carbonate, and other salts. Large reserves of this brine are found in deposits near Trona, California. As indicated in Table 3-1, a large direct carbonation sodium carbonate plant was recently constructed near these deposits.

The Solvay process produces sodium carbonate "synthetically" by the reaction of sodium chloride and limestone. Between the 1860's and the 1970's almost all sodium carbonate production was by the Solvay process. Since the mid-1960's production by the Solvay process has declined substantially while natural production has grown by roughly 500 percent. As indicated in Table 3-1, only one plant in the U.S. currently produces sodium carbonate by the Solvay process.

One reason for declining Solvay production has been increasing fuel costs. The Solvay process is more fuel intensive than any of the natural processes.

Environmental issues have also contributed to the decline in the production of sodium carbonate by the Solvay process. Substantial quantities of aqueous waste containing high concentrations of calcium chloride are produced in the Solvay process. Solvay sodium carbonate plants have traditionally disposed of these non-toxic wastes by discharging to a nearby waterway. Effluent guidelines developed under the Federal Water Pollution Control Act Amendment of 1972 for Solvay sodium carbonate plants were remanded; however, the 1972 Amendments introduced a National Pollutant Discharge Elimination System which provided for the establishment of effluent and water quality standards for discharges to a waterway. These standards had a severe impact on the cost of producing sodium carbonate by the Solvay Process.[5]

The future of sodium carbonate production in the U.S. by the Solvay process is limited. Allied Chemical Company (currently operating the only Solvay sodium carbonate plant in the U.S.) has issued statements to the effect that the construction of any new Solvay plants in the U.S. is very unlikely.[6] Allied made these statements on the basis of recent trends in sodium carbonate production and on the expected future trends in raw materials and energy prices. Personnel with the U.S. Bureau of Mines have also expressed the opinion that the construction of any new Solvay plants in the U.S. is unlikely.[7] (The Bureau of Mines compiles statistics on sodium carbonate production by the natural processes.)

New sodium carbonate plants in the U.S. will most likely use the monohydrate process, the direct carbonation process, or an anhydrous process.[8] (The anhydrous process is a new process which is currently in the developmental stage. It involves the same unit operations as the monohydrate process but the operating conditions of the crystallizer are such that anhydrous sodium carbonate rather than sodium carbonate monohydrate is produced in the crystallizers.) All additions to capacity which are currently in the planning stages involve the monohydrate process. Stauffer Chemical Company and FMC Corporation have expansions of approximately 270,000 Mg/yr (300,000 TPY) planned for completion in early 1981. Tenneco plans to complete construction on a new 0.91 million Mg/yr (1.0 million TPY) plant in Wyoming by 1983.[10]

Sodium carbonate plants using one of the natural processes typically consist of combinations of separate processing trains. For example, an existing plant and a planned new plant each consist of two trains of 454,000 Mg/yr (500,000 TPY) each. These trains have some shared equipment in areas such as ore crushing and liquor clarification, but major processing equipment (such as calciners and dryers) is separate.

Because of the limited availability of natural gas, future plants are expected to make greater use of coal than existing plants. All existing monohydrate sodium carbonate plants except one currently use gas-fired calciners. The newest monohydrate plant in operation uses coal-fired calciners, and a new plant planned for construction will also use coal-fired calciners.

3.1.2 Process Description

As noted in Section 3.1.1, four different processes are used in the U.S. for the production of sodium carbonate. These processes are described in Sections 3.1.2.1 through 3.1.2.4. These descriptions are derived from reference 11.

3.1.2.1 Monohydrate Process. In the monohydrate process, sodium carbonate is produced by the mining and processing of trona ore. A block flow diagram for the process is shown in Figure 3-1. As indicated, the twelve processing steps can be divided into four major processing groups: mining and ore handling, calcining, purification, and product drying and handling.

Trona ore is mined by conventional room-and-pillar, longwall, continuous mining, and other techniques. Coal mining equipment which has been modified to handle the harder trona ore is primarily used. The ore may enter the processing train directly from the mine, or may be discharged to an ore stockpile. The ore from the stockpile or mine is crushed (usually by hammermills), and screened. Some producers use a single crushing/screening step, while others use two stages of crushing. A surge bin holds the ore between the two stages of crushing. Over-sized ore from the second crusher is recycled back to the second crusher. The sized ore enters a second surge bin which provides a continuous feed to the calcining operation.

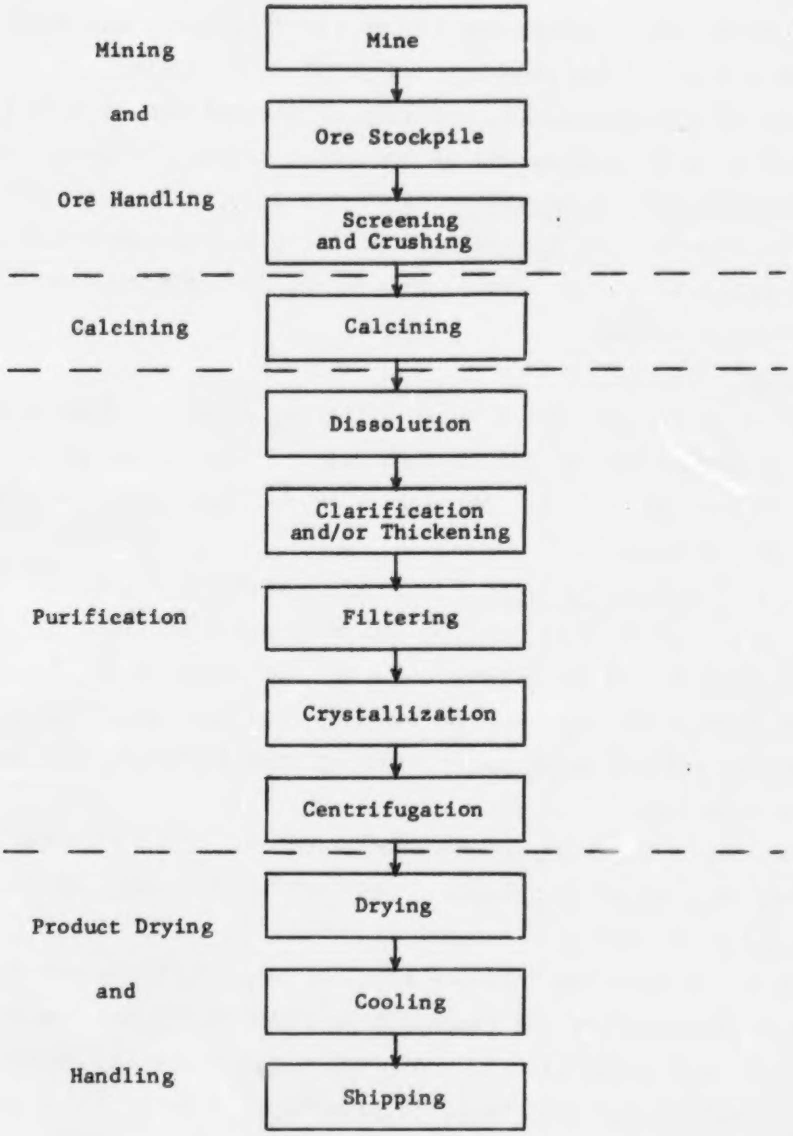
Mining
and
Ore Handling
Mine
Ore Stockpile
Screening and Crushing
Calcining
Calcining
Dissolution
Clarification and/or Thickening
Purification
Filtering
Crystallization
Centrifugation
Drying
Product Drying
and
Handling
Cooling
Shipping

Figure 3-1. Process flow diagram of the monohydrate process

In the calciner, the crushed and sized ore is heated to approximately 200°C (400°F). Carbon dioxide and water vapor are driven off, forming crude sodium carbonate. The calciners used in the mononydrate process may be fueled with either oil, gas, or coal since impurities resulting from the fuel will be removed in subsequent purification steps.

The crude sodium carbonate (which also contains insoluble impurities) is fed into leach tanks, or dissolvers, where the sodium carbonate dissolves. The liquor is sent to a clarifier where suspended solids are allowed to settle. These solids are further dewatered in a secondary clarifier. The underflow solids are then sent to a tailings pond for disposal. Overflow liquor from the clarifiers is pressure filtered and the solids are discarded. Activated carbon may be used to further remove impurities from the clear liquor.

Multiple effect evaporators are used to crystallize sodium carbonate monohydrate from the clear liquor. The mechanism of crystallization involves the increase in the concentration of dissolved sodium carbonate monohydrate until the liquor becomes super-saturated and crystallization is initiated. The increase in the concentration of dissolved sodium carbonate is achieved by heating the effects with steam. Vapor from one effect is used to heat the next effect. The crystallization is carried out at approximately 100°C (200°F). The slurry from the crystallizers is dewatered to approximately 5-10 percent water in a high speed centrifuge. The liquor is returned to the process and the sodium carbonate monohydrate ($Na_2CO_3 \cdot H_2O$) crystals are transferred to product dryers.

In the product dryers, both free and chemically bound moisture is evaporated from the sodium carbonate monohydrate at approximately 120 to 180°C(250 to 350°F). The dried product contains approximately 0.1% moisture. Dried product is fed onto vibrating screens for sizing. Oversize material is crushed and resized; fines are recycled to the process. At some facilities, air clarifiers or rotary tubes with external cooling water are used to cool the product. Product bulk density is about 960 kg/m^3 (60 lb/ft^3). The product is conveyed to intermediate storage silos and then to loading facilities. Most of the product is shipped by rail.

The operation of and emissions from calciners and dryers used in the monohydrate process are discussed in Section 3.2.

3.1.2.2 Sesquicarbonate Process. A block flow diagram of the sesquicarbonate process is shown in Figure 3-2. The processing steps in the sesquicarbonate process are very similar to those in the monohydrate process, but the order in which they occur is different.

Mining and ore handling operations are virtually the same as those discussed in Section 3.1.2.1 for the monohydrate process. Purification steps are also similar, but raw trona ore is purified before calcining rather than after calcining as in the monohydrate process. The crystallizer product is purified sodium sesquicarbonate rather than sodium carbonate monohydrate. In the one U.S. plant using the sesquicarbonate process, vacuum crystallizers rather than multiple effect evaporators are used. Sodium sesquicarbonate crystals from the crystallizers are centrifuged and then calcined.

In the calciners, the purified sodium sesquicarbonate is heated to approximately 200°C(400°F). Carbon dioxide and water vapor are driven off, forming pure sodium carbonate. This product has a bulk density of about 800 kg/m^3 (50 lb/ft^3). Some of the product is double calcined to heat densify it to a bulk density of about 960 kg/m^3 (60 lb/ft^3) or higher.

Since the calcination step follows purification, direct firing of the calciners with coal or high sulfur oil would result in product contamination with coal ash and sulfur. This makes the use of these fuels impractical. Steam tube calciners or gas-fired calciners are thus used in the sesquicarbonate process to prevent product contamination. This incapability to use dirty fuels for calcination is one major disadvantage of the sesquicarbonate process over the monohydrate process.

The sesquicarbonate process is also less fuel efficient than the monohydrate process. It is difficult to achieve the high temperatures required for calcination in steam-tube calciners. Also, in the monohydrate process a high density product is produced directly while in the sesquicarbonate process light product must be re-calcined in high temperature gas-fired calciners to produce the higher density product.

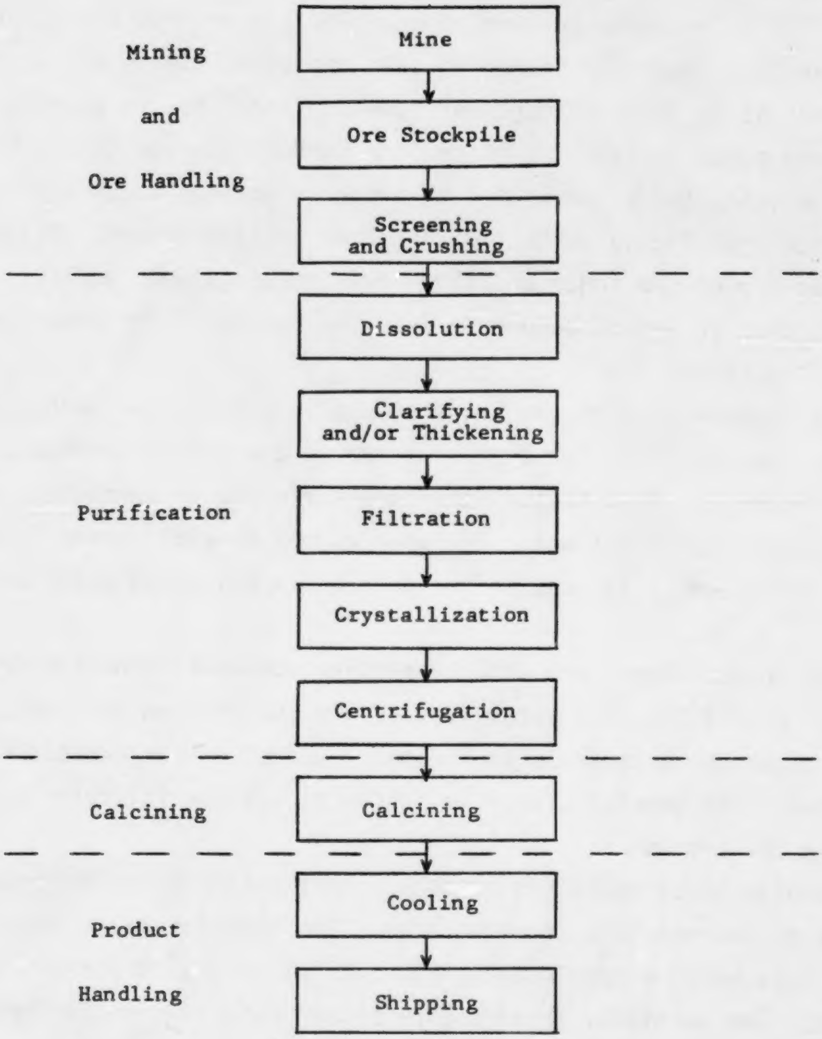
Mining
and
Ore Handling
Mine
Ore Stockpile
Screening and Crushing
Dissolution
Clarifying and/or Thickening
Purification
Filtration
Crystallization
Centrifugation
Calcining
Calcining
Cooling
Product
Handling
Shipping

Figure 3-2. Process flow diagram of the sesquicarbonate process

3.1.2.3 Direct Carbonation Process. In the direct carbonation process, sodium carbonate is produced from brine containing sodium sesquicarbonate, sodium carbonate, and other salts. A block flow diagram of the process is shown in Figure 3-3.

The brine is prepared by pumping recycled liquor from the plant and makeup water into naturally occurring salt deposits. Salts are dissolved by the liquor as it flows through the porous mineral bed to pumping wells. These pumps deliver the brine to a surface storage tank. From this storage tank, the brine is fed to a precarbonation tower where countercurrent gas-liquid contact with carbon dioxide occurs. Brine is fed into the top of the tower and flows over polyethylene saddles. A weak carbon dioxide stream pumped in from the bottom of the tower partially carbonates the brine.

Further carbonation of the brine occurs in primary and secondary carbonation towers. This carbonation converts the sodium carbonate to sodium bicarbonate. This sodium bicarbonate mixture is corrosive, so all vessel interiors are lined. The weak carbon dioxide stream from the outlet of these towers is used in the previously discussed precarbonation step.

Vacuum crystallizers are used to recover sodium bicarbonate from the brine. Conditions of crystallization are chosen such that the yield of sodium bicarbonate crystals is maximized and other compounds are not precipitated. The crystal slurry is filtered, and the filtrate is returned to the process.

The sodium bicarbonate filter cake enters steam heated predryers where some of the moisture is evaporated. The temperature in these predryers is kept below approximately 50°C (122°F) so that no carbon dioxide is evolved. The partially dried sodium bicarbonate is then further heated in a steam heated calciner. Carbon dioxide and all remaining water vapor are driven off, forming impure sodium carbonate. The carbon dioxide evolved is recycled to the brine carbonators.

Impure sodium carbonate from the calciner is bleached with sodium nitrate to burn off discoloring materials. The gas- or oil-fired rotary bleachers operate at 450°C (850°F).[12] The light sodium carbonate from

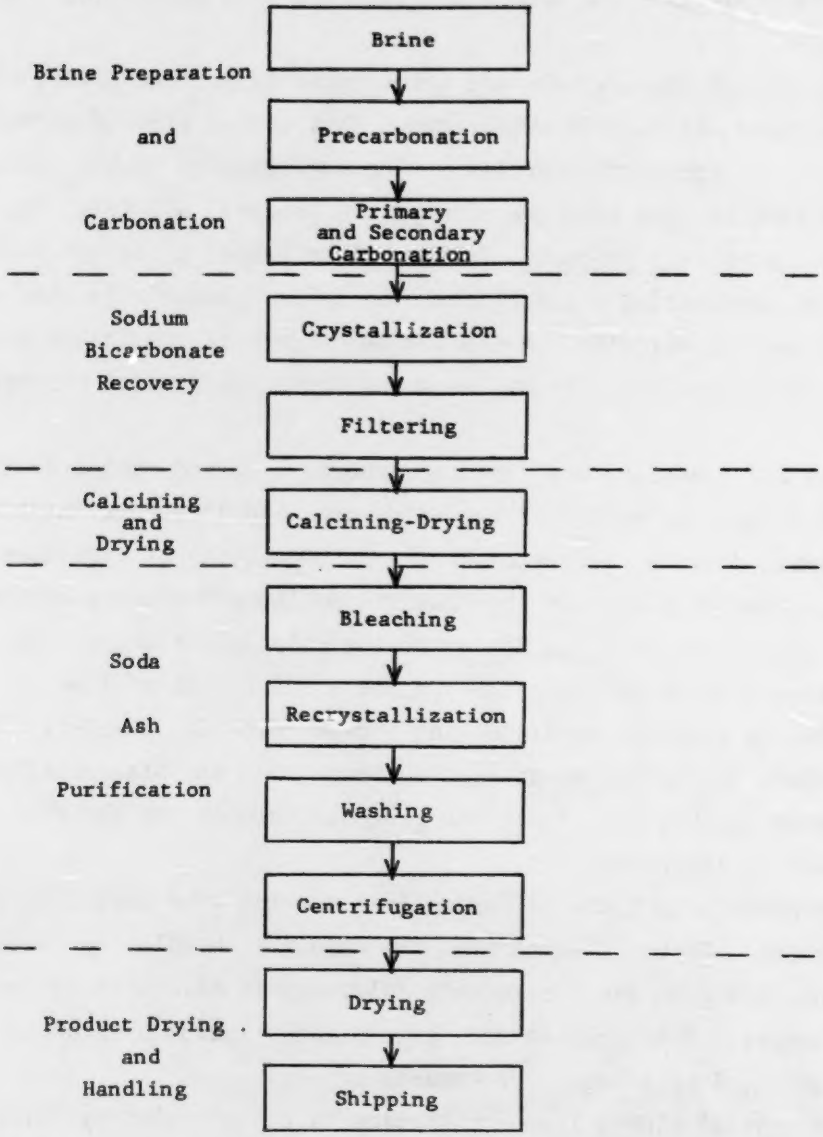
Brine
Brine Preparation
and
Carbonation
Precarbonation
Primary and Secondary Carbonation
Sodium
Bicarbonate
Recovery
Crystallization
Filtering
Calcining
and
Drying
Calcining-Drying
Bleaching
Soda
Ash
Purification
Recrystallization
Washing
Centrifugation
Drying
Product Drying
and
Handling
Shipping

Figure 3-3. Process flow diagram of the direct carbonation process

the bleacher is recrystallized to sodium carbonate monohydrate. Larger, denser crystals are produced by this step. The crystal slurry is filtered, and the filter cake is washed to remove impurities such as sodium sulfate and sodium chloride. The washed crystals are then centrifuged to about 5% moisture.

The monohydrate crystals are transferred to product dryers where free and bound moisture is evaporated. This drying step is comparable to that in the monohydrate process. The bulk density of the product is also the same as that from the monohydrate process, 960 kg/m^3 (60 lb/ft^3).

3.1.2.4 Solvay Process. In the Solvay process, sodium carbonate is made by carbonating a sodium chloride brine. Ammonia is used as a catalyst for the reaction. A block flow diagram of the Solvay process is shown in Figure 3-4. As may be seen, there are 9 major processing steps.

Coke and limestone are fired to produce lime and carbon dioxide. Air is fed into the bottom of the kiln; coke and limestone enter at the top. Carbon dioxide, generated by the decomposition of limestone and the combustion of carbon in the coke, is pulled off the top of the kiln. Lime is discharged from the bottom of the kiln into storage bins. It is then slaked with excess water to produce a thick milk of lime.

Brine is prepared by dissolving sodium chloride in water. This brine enters the top of an absorption tower, and ammonia-containing gases enter the bottom. The brine descends through the absorber countercurrent to the rising gas.

The ammoniated brine is pumped into the top of a series of carbonation towers. Carbon dioxide from the lime kiln bubbles up through the solution. Gas from the bicarbonate calciners is also used in the carbonation towers. This process step precipitates sodium bicarbonate from the solution, liberating large amounts of heat.

The crystal slurry from carbonation is concentrated by filtration where free and fixed ammonia are recovered for use in the ammonia absorption. Free ammonium compounds are decomposed by heat, and fixed ammonia is recovered by the reaction of lime with ammonium chloride. A calcium chloride waste stream is generated from this reaction.

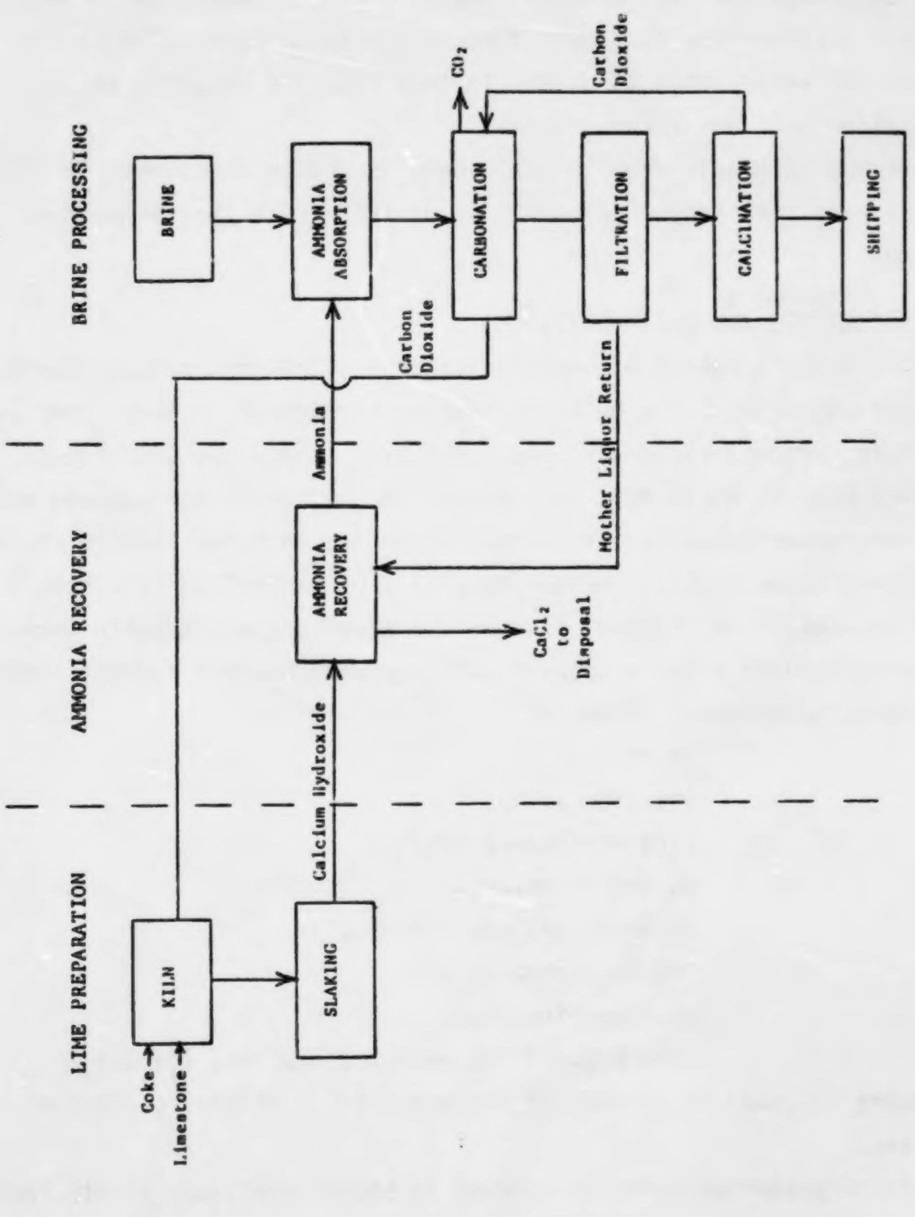
LIME PREPARATION
AMMONIA RECOVERY
BRINE PROCESSING
Coke
Limestone
KILN
SLAKING
Calcium Hydroxide
AMMONIA RECOVERY
CaCl₂ to Disposal
Mother Liquor Return
Ammonia
Carbon Dioxide
BRINE
AMMONIA ABSORPTION
CARBONATION
CO₂
FILTRATION
CALCINATION
Carbon Dioxide
SHIPPING

Figure 3-4. Solvay Process.

The filter cake of crude sodium bicarbonate is washed to remove impurities and then calcined to drive off carbon dioxide and water. The usual apparatus for this process step is a rotary steam tube dryer; however, a steam tube fluid bed dryer may also be used. The carbon dioxide and water vapor liberated in this step are recycled to the carbonation section of the process.

Sodium carbonate from the calciners is cooled and stored in silos. From storage, the sodium carbonate is distributed either in bulk or packaged.

3.2 FACILITIES AND THEIR EMISSIONS

There are a number of emission sources within the natural sodium carbonate industry. The emission sources considered in this study are calciners, dryers, bleachers, and predryers. These are all process emission sources which emit significant quantities of particulate matter.

Many potential emission sources in sodium carbonate plants are not considered in this study because they will be controlled as a result of other studies. For example, boilers for steam and electricity generation are being handled under a special category with boilers for all industries. Many emission sources, including

crushers,
grinding mills,
screening operations,
bucket elevators,
conveyor transfer points,
bagging operations,
storage bins, and
fine product (20 mesh and smaller) loading

are being included in a study of the nonmetallic mineral processing industry.

Other potential emission sources in sodium carbonate plants include stockpiling, conveying, and windblown dusts. These are fugitive sources common to many mineral industries rather than process sources, and a specialized program would be required to identify and study them. Based on data presented by the Wyoming Department of Environmental Quality,[13] fugitive emissions account for less than 10 percent of the total uncontrolled emissions from sodium carbonate plants. For these reasons, process emission sources are emphasized in this study and general fugitive emissions are not considered.

Dissolvers (and dissolver-crystallizers) are not considered in this study because they are not significant emission sources. Uncontrolled emissions from dissolvers are very small compared to the other emission sources considered. Moreover, all dissolvers built since about 1973 are currently controlled in order to comply with state opacity regulations or to control internal dusting problems. Because dissolver emissions are so small compared to the other process emission sources considered, control of dissolver emissions to a more stringent level would have very little impact on national emissions.

As discussed in Section 3.1, the Solvay process and the sesquicarbonate process are not expected to be used in future plants. Thus, emission sources specific to these processes will not be discussed in this section. Future sodium carbonate plants are expected to use the monohydrate process or the direct carbonation process. As can be seen in the process flow diagrams in Section 3.1.2, neither of these processes employ all four of the emission sources considered in this study. The emission sources specific to the monohydrate process are calciners and dryers, and those specific to the direct carbonation process are predryers, bleachers, and dryers.

Calciners are used in the direct carbonation process, but (as noted in Section 3.1.2.3) exit gas from these calciners is scrubbed for particulate removal and recycled to the carbonation towers. Exit gas from the carbonation towers is sent to the boilers. Potential pollutants are thus removed in the process equipment and in the pollution control equipment on the boilers before the gases are emitted to the atmosphere.[14] Therefore, calciners in the direct carbonation process are not considered to be emission sources.

Each of the facilities being considered in this study of the sodium carbonate industry is discussed in this section. The discussion is divided into four sections, one each for calciners, dryers, predryers, and bleachers.

3.2.1 Calciners

3.2.1.1 Description. Calciners employed in the monohydrate process are continuously fed, direct-fired, cocurrent, rotary units. They consist of a combustion furnace and an inclined rotating cylinder. Structurally, the cylinder, or rotary section, is similar to that of the direct-fired, cocurrent, rotary dryer illustrated in Figure 3-9. The cylinder is constructed of an outer metal shell and may have an inner refractory brick lining. All or part of the cylinder may be insulated to reduce heat losses to the environment.

The solid feed is introduced at the elevated end of the cylinder and moves toward the discharge as a result of gravity and of the rotary motion of the cylinder. Lifting flights along the inside of the cylinder aid the movement of the solids and provide intimate mixing with the hot combustion gases which enter from the furnace. The combustion gases flow axially in the same direction that the solids move and transfer heat to the solids as they move through the calciner.

Calciner feed in the monohydrate process consists of crushed and screened trona ore. This ore typically consists of 86 to 95 percent sodium sesquicarbonate, 5 to 12 percent gangue (clays and other insoluble impurities) and approximately 2 percent water. As the ore is heated to 150-200°C (300-390°F) it decomposes or calcines. Carbon dioxide and water are driven off, and crude sodium carbonate is formed by the following reaction:

$$2(Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O)\ (s) \rightarrow 3\ Na_2CO_3(s) + 5H_2O(g) + CO_2(g)$$

Heat of reaction for this endothermic reaction is 44.224 kcal/g-mole (79,603 Btu/lb-mole) at 25°C (77°F). At calcination temperatures above 200°C (390°F), organic impurities are burned off; however, at these temperatures soluble sodium silicates are produced by reactions between sodium carbonate and the clays.[15] These soluble compounds can interfere with crystallization in the process crystallizers.

Coal, gas, and oil-fired rotary calciners are used in the monohydrate process. Gas firing is currently the most common, and oil firing is the least common. There are no calciners designed to burn oil only, but gas-fired calciners are designed to burn oil during gas shortages. At present, coal-fired calciners are used in only one operating plant. However, due to expected long term shortages of natural gas, a trend to coal firing is anticipated.

Combustion furnaces on calciners may be of the type illustrated in Figure 3-9 for a rotary gas-fired dryer, or they may be separate units connected to the rotary section only by ductwork. The type of furnace is dependent on the type of fuel combusted.

Coal-fired calciners require a separate combustion furnace with a coal feeder and rather complicated control equipment. The combustion furnace for gas-or oil-fired calciners is fairly simple, and may open directly into the rotary part of the calciner as illustrated in Figure 3-9. As a result of this arrangement, the solids being calcined are exposed to the flame front, and heat transfer by radiation may be significant. High overall effective heat transfer coefficients result. Also, the temperature of the combustion gases in gas- or oil-fired calciners is generally higher than in coal-fired calciners.

As a result of the higher effective heat transfer coefficients and the higher combustion gas temperatures in gas- or oil-fired calciners, higher heat transfer rates per unit mass of solids are achievable. Thus, more solids can be processed in the same size calciner and less combustion gas per unit mass of solids is required.

The reported design capacities of calciners used by manufacturers employing the monohydrate process range from approximately 40 to 163 Mg/h (44 to 180 TPH) of ore feed. However, in some cases the calciner is normally operated at a rate which is higher than the design operating capacity. (For example, one calciner is normally operated at a rate which is approximately 20 percent higher than the design value.) This is possible because equipment such as calciners is usually over-designed to allow for design errors; i.e. its actual maximum operating capacity is sometimes greater than its design operating capacity. In an industry such as the sodium carbonate industry, where the market demand is relatively strong, plant operators will often run equipment at its maximum capacity, providing this will not damage equipment or overload other equipment in the process.

Calciners at new plants are expected to have capacities of about 118 Mg/h (130 TPH). A calciner of approximately this size would be required to process enough ore to produce 454,000 Mg/yr (500,000 TPY) of sodium carbonate, based on an operating factor of 85% and recovery of 90% of the available sodium carbonate in the ore. Larger calciners are not expected to be built because of regulations on the size of equipment which can be shipped by rail. Calciners significantly smaller are currently in use only in older plants.

3.2.1.2 Emissions. Calciners are the largest source of particulate emissions from plants using the monohydrate process. These particulates consist of sodium carbonate and inerts. The exit gas from coal fired calciners will contain fly ash as well.

Particulate emissions from calciners are affected by the gas velocity and the particle size distribution of the ore feed. Gas velocity through the calciner affects the degree of turbulence and agitation. As the gas velocity increases, the rate of increase in the total emission rate of particulates steadily increases. (Not enough information is available to define the effect on particulate concentration.) Particle size distribution of the ore affects particulate emissions because small particles are more easily entrained in a moving stream of gas than are larger particles.

Particulate emission factors, particulate concentrations, and exit gas flow factors for gas and coal-fired calciners as measured in various source tests on calciners operating at various production rates are presented in Table 3-2. Estimated uncontrolled particulate emission rates, particulate concentrations, and exit gas flow rates extrapolated from EPA test data presented in Table 3-2 are presented in Table 3-3 for small, medium, and large gas and coal-fired calciners. As suggested by the wide range of exit gas flow rates in industry data presented in Table 3-2, the actual variation in gas flow rates, particulate concentrations, and particulate emission rates for these size calciners may be much wider than indicated in Table 3-3.

Based on the reported values of particulate emission rate, product loss

TABLE 3-2. UNCONTROLLED EMISSION PARAMETERS FOR CALCINERS IN THE MONOHYDRATE PROCESS

Source of Data	Fuel	Calciner Size[a]	Particulate Emission Factor kg/Mg ore	Particulate Emission Factor (lb/ton)ore	Particulate g/dNm^3	Concentration (gr/dscf)	Exit Gas Flow Factor[b] dNm^3/Mg	Exit Gas Flow Factor[b] dscf/ton
EPA Test Plant A[c]	Coal	M	222	442	117	51.2	1890	60,500
EPA Test Plant A	Coal	M	213	425	122	53.1	1750	56,000
EPA Test Plant B-1[d]	Gas	M	115	230	167	72.8	696	22,300
EPA Test Plant B-1	Gas	M	195	389	249	109	774	24,800
EPA Test Plant B-1	Gas	M	178	356	263	115	677	21,700
EPA Test Plant B-2[d]	Gas	L	174	348	238	104	734	23,500
EPA Test Plant B-2	Gas	L	157	314	216	94.3	727	23,300
EPA Test Plant B-2	Gas	L	117	233	177	77.5	656	21,000
Industry Data-Plant A[e]	Coal	M	—[f]	—[f]	—[f]	—[f]	1620-1800	52,000-57,500
Industry Data-Plant A (Avg.)	Coal	M					1720	55,000
Ind. Data-Plant B-1	Gas	M					612-665	19,600-21,300
Ind. Data-Plant B-1 (Avg.)	Gas	M					640	20,500
Ind. Data-Plant B-2	Gas	L					540-590	17,300-18,900
Ind. Data-Plant B-2 (Avg.)	Gas	L					574	18,400
Ind. Data-Plant C-1	Gas	S					834-996	28,300-31,900
Ind. Data-Plant C-1 (Avg.)	Gas	S					958	30,700
Ind. Data-Plant C-2	Gas	M					618-634	19,800-20,300
Ind. Data-Plant C-2 (Avg.)	Gas	M					624	20,000
Ind. Data-Plant D	Gas	M					684-1360	21,900-43,500
Ind. Data-Plant D (Avg.)	Gas	M					946	30,300
Ind. Data-Total Range	Gas	S-L					540-1360	17,300-43,500
Ind. Data-Total Range	Coal	M					1620-1890	52,000-60,500

[a] Small, 40-50 Mg/hr (44-55 tph); Medium, 80-125 Mg/hr (88-138 tph); Large, 200-220 Mg/hr (221-243 tph).

[b] At outlet of control device. EPA tests showed discrepancies between inlet and outlet measurements, and outlet measurements are believed to be more accurate. Dry flow rate should not be changed by control device.

[c] Reference 16.

[d] Reference 17.

[e] Reference 18.

[f] Uncontrolled emissions were not measured.

TABLE 3-3. UNCONTROLLED PARTICULATE EMISSIONS FROM CALCINERS IN THE MONOHYDRATE PROCESS

(Extrapolated from EPA Test Data.[a])

Size	Ore Feed Rate Mg/h (TPH)	Fuel	Particulate Concentration g/dNm^3 (gr/dscf)	Particulate Emission Rate kg/h (lbs/h)	Exit Gas Flow Rate dNm^3/min (dscf/min)	Particulate Emission Factor kg/Mg (lb/ton)
Small	40 (44)	Coal[b]	110 (52)	8.5×10^3 - 8.8×10^3 1.9×10^4 - 1.8×10^4	1.2×10^3 - 1.3×10^3 (4.1×10^4 - 4.4×10^4)	213-222 (425-442)
		Gas[b]	167-263 (73-115)	4.6×10^3 - 7.8×10^3 1.0×10^4 - 1.7×10^4	4.5×10^2 - 5.2×10^2 (1.6×10^4 - 1.8×10^4)	115-195 (230-389)
Medium	118 (130)	Coal	110 (52)	2.5×10^4 - 2.6×10^4 (5.5×10^4 - 5.7×10^4)	3.4×10^3 - 3.7×10^3 (1.2×10^5 - 1.3×10^5)	213-222 (425-442)
		Gas	167-263 (73-115)	1.4×10^4 - 2.3×10^4 (3.0×10^4 - 5.1×10^4)	1.3×10^3 - 1.5×10^3 (4.7×10^4 - 5.4×10^4)	115-195 (230-389)
Large	200 (220)	Coal[b]	116 (52)	4.3×10^4 - 4.4×10^4 (9.4×10^4 - 9.7×10^4)	5.8×10^3 - 6.3×10^3 (2.1×10^5 - 2.2×10^5)	213-222 (425-442)
		Gas	178-238 (78-104)	2.3×10^4 - 3.5×10^4 (5.1×10^4 - 7.7×10^4)	2.2×10^3 - 2.4×10^3 (7.7×10^4 - 8.6×10^4)	117-174 (233-348)

[a] References 19 and 20.

[b] Particulate concentration is the same as that which was measured for a medium size calciner during source tests. Reported particulate emission rate and exit gas flow rate are based on values for a medium size calciner weighted for the different ore feedrate.

as a result of particulate loading in the exit gas is about 20 to 25 percent of ore feed. Most of this material, however, is routinely recovered in cyclones and in subsequent particulate removal equipment and returned to the process.

Particle size distribution data for emissions from gas-and coal-fired calciners as measured in EPA source tests are presented in Figures 3-5 and 3-6.

Sulfur oxides are produced from fuel combustion. The quantities produced depend upon the sulfur content of the fuel. The sulfur content of natural gas is generally insignificant. The sulfur content of coal and oil is significant; however, it may vary widely. No major seasonal variations in sulfur oxide levels are expected; however, minor variations may result when fuel oil is substituted for gas during winter months when there are natural gas curtailments.

Sulfur dioxide concentrations in the exit gas from a coal-fired calciner were measured during EPA source tests in May, 1979. The results of these measurements indicate an emission factor of 0.0076 kg/Mg (0.0152 lb/ton) of ore feed. However, calculations based on the sulfur content of coal used at this plant and emission factors in an EPA publication[21] indicate that the sulfur dioxide emission factor should be approximately 1 kg/Mg (2 lb/ton) of ore feed. Apparently, sulfur dioxide is removed from the combustion gases by reacting with sodium carbonate in the calciner before the gases are exhausted.

In addition to the emissions discussed above, organics are emitted from calciners. These organics may be responsible for the bluish tint of the exit gases observed at three plants.[22,23,24] (The blue haze may also be due to fine particulates.) Concentrations and emission factors for organics in the exit gases of calciners are reported in Table 3-4.

The source of the organics has not been identified; however, there are organics present in the feed in the form of oil shale. At the calcination temperatures, these may vaporize or be partially combusted. In addition, some organics may result from partial or incomplete combustion of the fuel.

TABLE 3-4. UNCONTROLLED ORGANIC EMISSIONS FROM CALCINERS[a]

Source of Data[a]	Fuel	Calciner Size[c]	Organic Concentrations ppm[b]
EPA Test Plant A[d]	Coal	M	30
EPA Test Plant A	Coal	M	22
EPA Test Plant B[e]	Gas[f]	M	917
EPA Test Plant B	Gas[f]	M	2587
EPA Test Plant B[e]	Gas	L	47
EPA Test Plant B	Gas	L	178
EPA Test Plant B	Gas	L	222

[a] Reported on the basis of total organics as methane.

[b] By volume as methane. Emissions as specific compound would be (ppm as methane) divided by the number of carbon atoms in the compound.

[c] Medium, 80-125 Mg/hr (88-138 tph); Large, 200-220 Mg/hr (221-243 tph).

[d] Reference 25

[e] Reference 26

[f] These measurements were taken with the calciner operating at low capacity, and may not be representative of normal operation.

[g] These emission factors are approximations only. Organics were reported as ppm methane; the organic species actually present were not determined.

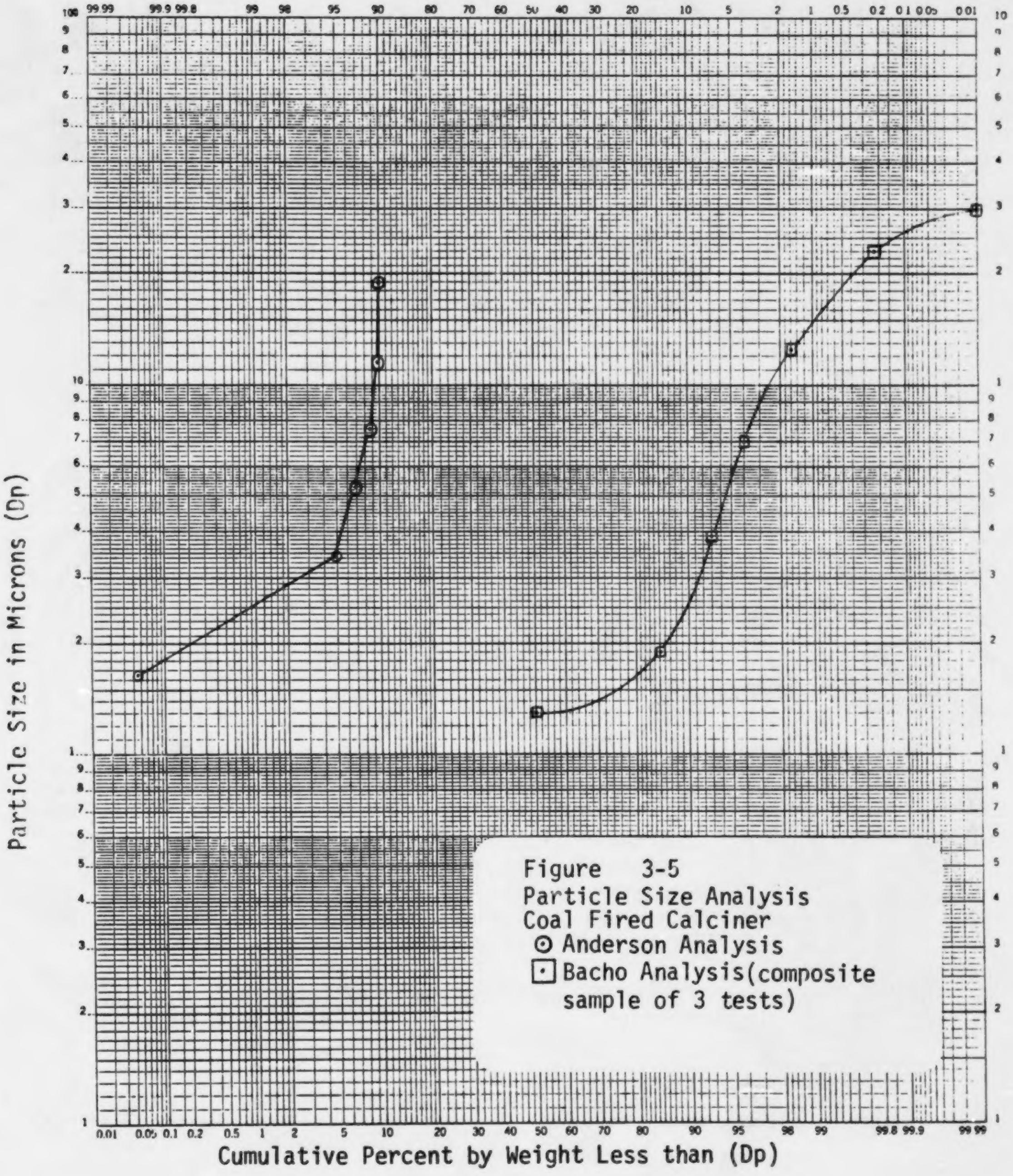

Figure 3-5
Particle Size Analysis
Coal Fired Calciner

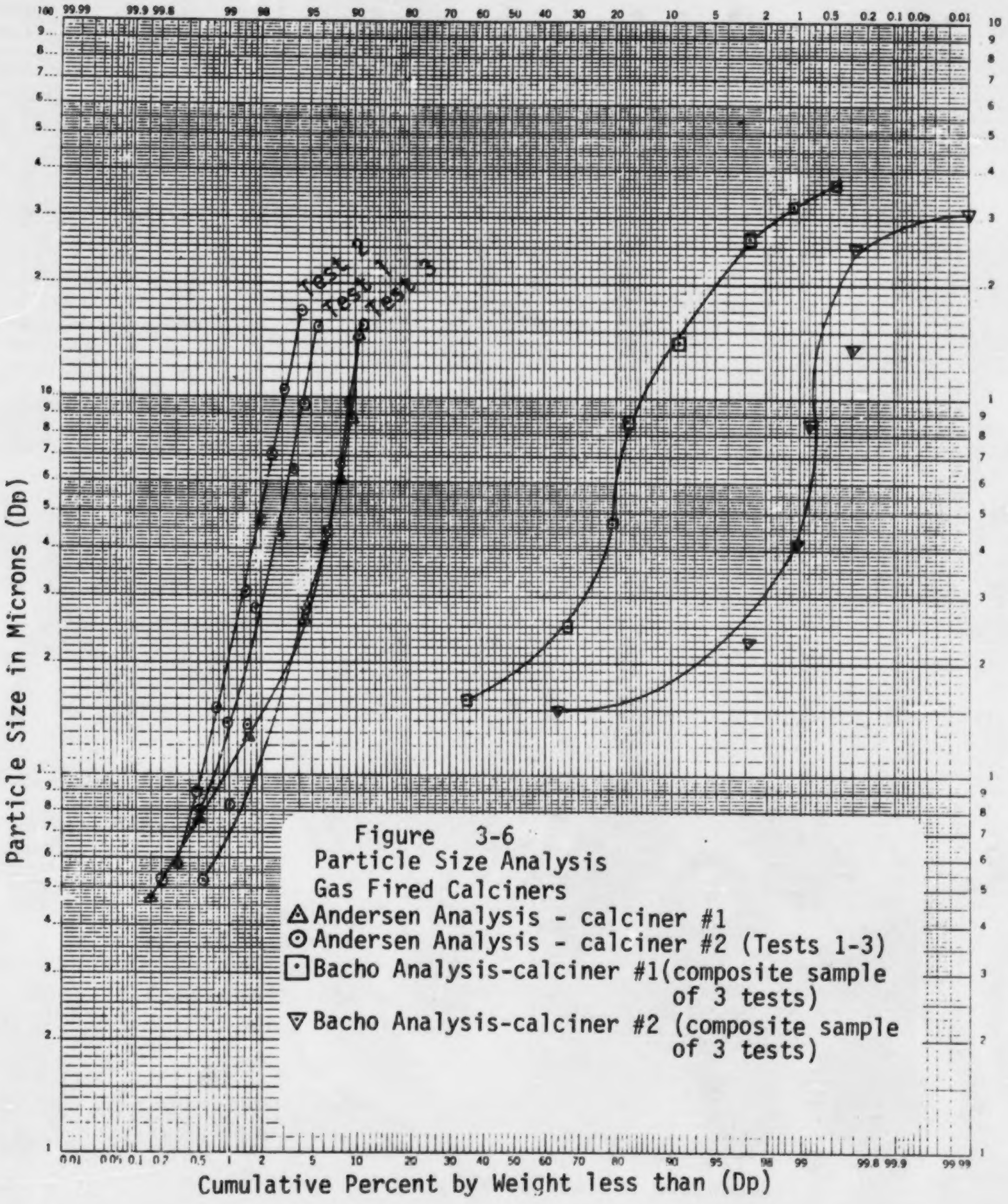

Figure 3-6
Particle Size Analysis
Gas Fired Calciners

3.2.1.3 Mass and Energy Balances. Energy usage factors, exit gas flow factors, exit gas temperature, exit gas moisture content, and the mass ratio of ore feed to sodium carbonate final product are presented in Table 3-5. Available information does not indicate any significant variation in these values for different size calciners. The bases for the reported values are given in the footnotes to Table 3-5.

As noted in Section 3.2.1.1, a capacity of about 118 Mg/h (130 TPH) of ore feed is expected to be a typical size for future calciners. Energy usage rate, material flow rates, and exit flow rate for a calciner of this size are presented in Figure 3.6.

3.2.2 Dryers

3.2.2.1 Description. Dryers are used in both the monohydrate and direct carbonation processes to remove free and hydrated water from sodium carbonate monohydrate crystals. Hydrated water is removed by the following reaction:

$$Na_2CO_3 \cdot H_2O(s) \longrightarrow Na_2CO_3(s) + H_2O\ (g)$$

The heat of reaction is 13.7 kcal/g mole (24,660 Btu/lb mole) at 25^0C (77^0F). Supplying the heat to drive this reaction consumes the major portion of the heat required for drying. Theoretically, the dry monohydrate crystals contain about 15 percent hydrated water by weight. Estimates of the percentage of free water in the monohydrate crystal feed to dryers in the monohydrate process range from about 5 percent to 15 percent.[30,31,32] The free water content of the monohydrate crystal feed in the direct carbonation process is approximately 5 percent. Dryers in both processes achieve essentially complete water removal.

Three types of dryers are used for product drying in the monohydrate and direct carbonation processes: rotary steam tube, rotary gas fired, and fluid bed steam tube. All three dryer types are used by producers using the monohydrate process. The one producer using the direct carbonation process uses rotary steam tube dryers. These are operated in a similar manner to rotary steam tube dryers used by producers employing the monohydrate process. A general description of the operation of each type of dryer follows.

TABLE 3-5. VALUES FOR MASS AND ENERGY BALANCES ON CALCINERS IN THE MONOHYDRATE PROCESS

Fuel	Energy Usage Factor[a] J/Mg of Ore (Btu/ton of ore)	Exit Gas Flow Factor[b] dNm³/Mg of Ore (dscf/Ton of Ore)	Exit Gas Temperature[b] °C (°F)	Exit Gas Moisture Content[b] %	$\frac{\text{Mg of Calciner Feed (trona ore)}}{\text{Mg of Final Product (sodium carbonate)}}$[c]
Coal	$1.6\times10^{9} - 1.7\times10^{9}$ $(1.4\times10^{6} - 1.5\times10^{6})$ d	$1.6\times10^{3} - 1.7\times10^{3}$ $(5.1\times10^{4} - 5.5\times10^{4})$	200 - 230 (400 - 450)	~20	1.9
Gas	$\sim1.1\times10^{9}$ $(\sim9.5\times10^{5})$ e	$6.6\times10^{2} - 7.1\times10^{2}$ $2.2\times10^{4} - 2.4\times10^{4}$	188 - 200 (370 - 400)	30 - 38	1.9

a. The energy usage factors are those which would be supplied by the gross heating value of the fuel.

b. Based on measurements on medium size calciners. (References 27, 28.)

c. Based on an overall material balance on a monohydrate plant. It is assumed that the trona ore contains 83% sodium sesquicarbonate and that 90% of the available Na_2CO_3 in the trona ore is recovered as final product.

d. The lower value of the range is based on mass and energy balances (ore moisture content ~2%) while the upper value is based on data reported in a 1977 Emission Inventory. (Reference 29)

e. The reported value is based on mass and energy balances (ore moisture content ~2%).

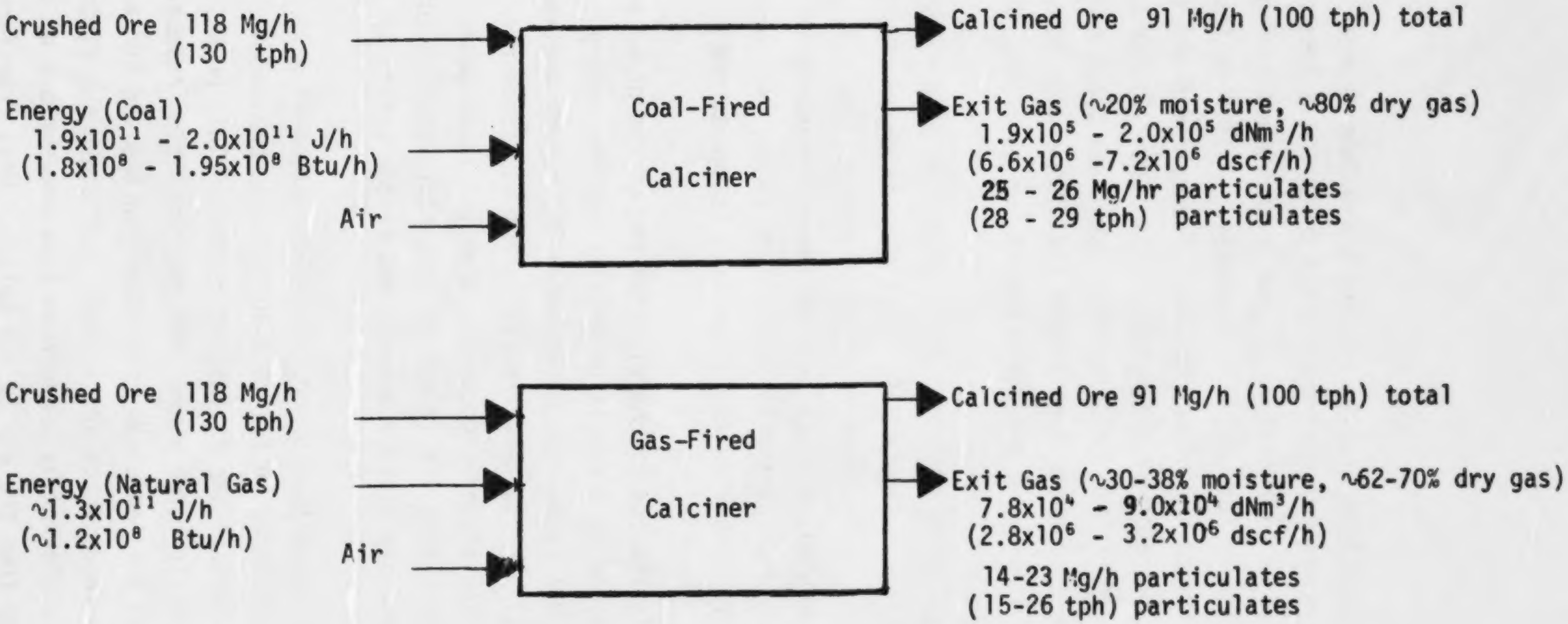
Crushed Ore 118 Mg/h
(130 tph)
Energy (Coal)
1.9x10¹¹ - 2.0x10¹¹ J/h
(1.8x10⁸ - 1.95x10⁸ Btu/h)
Air
Coal-Fired
Calciner
Calcined Ore 91 Mg/h (100 tph) total
Exit Gas (~20% moisture, ~80% dry gas)
1.9x10⁵ - 2.0x10⁵ dNm³/h
(6.6x10⁶ -7.2x10⁶ dscf/h)
25 - 26 Mg/hr particulates
(28 - 29 tph) particulates
Crushed Ore 118 Mg/h
(130 tph)
Energy (Natural Gas)
~1.3x10¹¹ J/h
(~1.2x10⁸ Btu/h)
Air
Gas-Fired
Calciner
Calcined Ore 91 Mg/h (100 tph) total
Exit Gas (~30-38% moisture, ~62-70% dry gas)
7.8x10⁴ - 9.0x10⁴ dNm³/h
(2.8x10⁶ - 3.2x10⁶ dscf/h)
14-23 Mg/h particulates
(15-26 tph) particulates

Figure 3-7. Material flow rates and energy usage rates for a medium size calciner in a plant using the monohydrate process

3.2.2.1.1 Rotary steam tube dryers. Rotary steam tube dryers consist essentially of a metal cylinder with steam tubes fixed lengthwise inside the cylinder. An illustration of one is presented in Figure 3-8. The end in which feed is introduced is normally elevated to facilitate the flow of solids toward the discharge end. The cylinder and the steam tubes rotate about the axis of the cylinder. As the cylinder and steam tubes rotate, the material to be dried falls over the steam tubes and is heated. This heat evaporates free liquid and dissociates bound liquid. Air is admitted at one end and withdrawn at the other end to remove evaporated liquid.

3.2.2.1.2 Rotary gas-fired dryers. An illustration of a rotary gas fired dryer is presented in Figure 3-9. This type of dryer consists of a combustion furnace and an inclined rotating cylinder. The cylinder is constructed of an outer shell and may have an inner refractory lining. Lengthwise, the shell is either partially or entirely lined. All or part of the cylinder may be insulated to reduce heat losses to the environment.

The wet solids are introduced at the elevated end of the dryer and move toward the discharge end as a result of gravity and the rotary motion of the cylinder. Hot combustion gases enter the rotary section and flow either cocurrently or countercurrently to the direction of solids flow (Figure 3-9 illustrates a cocurrent dryer). These gases heat the solids to evaporate free liquid and to dissociate bound liquid. Significant amounts of heat may also be transferred to the solids by flame radiation.

3.2.2.1.3 Fluid bed steam tube dryer. An illustration of a fluid bed steam tube dryer is presented in Figure 3-10. Air is preheated and introduced into a plenum beneath the fluidizing chamber. This preheated air then rises through a distributor plate into the fluidizing chamber. The wet solids to be dried are entrained (fluidized) in the air stream at the level of the steam tubes which are located just above the distributor plate. Heat is transferred by convection from the surface of the steam tubes to the air and from the air to the solids. Heat transferred to the solids evaporates free liquid, and dissociates bound liquid. Evaporated liquid is carried out of the dryer in the air stream.

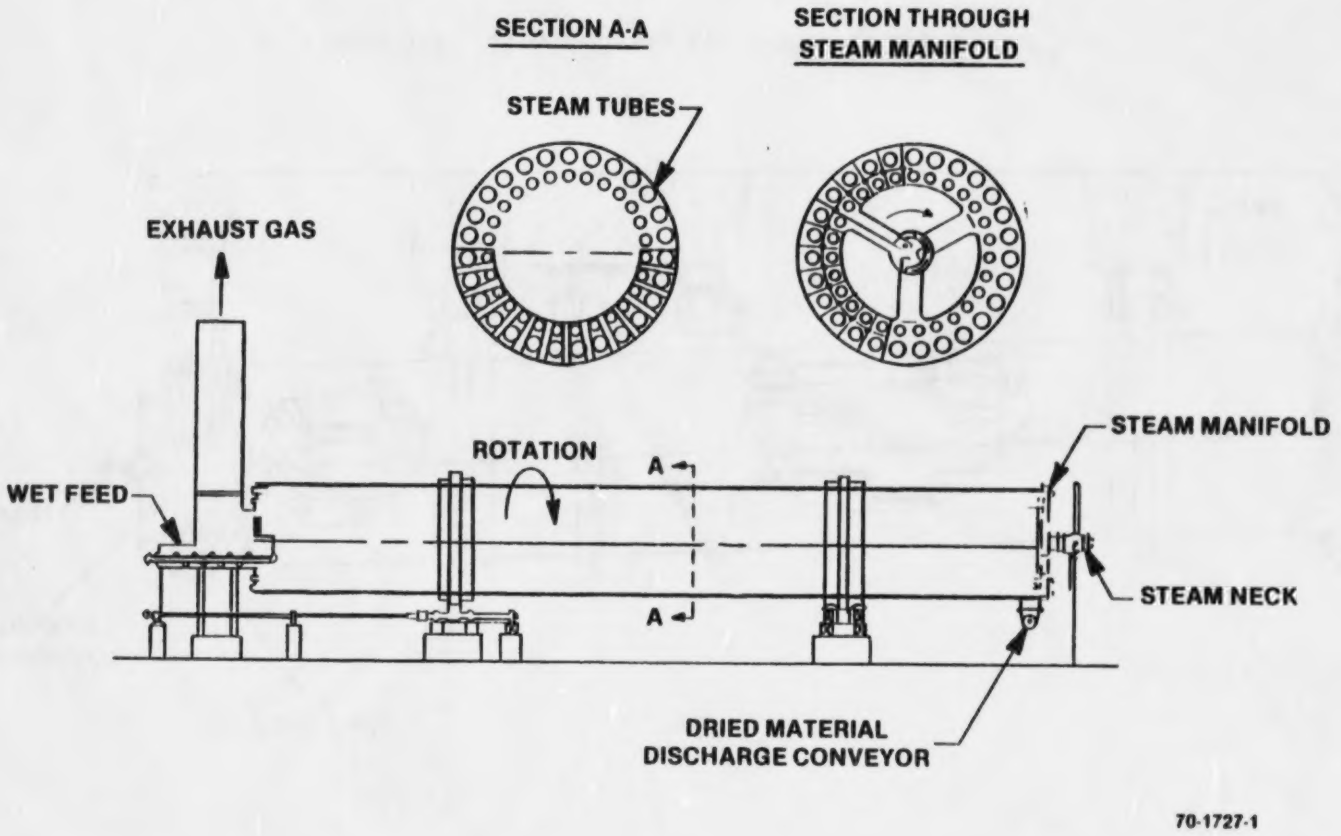
SECTION A-A
SECTION THROUGH STEAM MANIFOLD
STEAM TUBES
EXHAUST GAS
ROTATION
A
A
STEAM MANIFOLD
WET FEED
STEAM NECK
DRIED MATERIAL DISCHARGE CONVEYOR
70-1727-1

Figure 3-8. Steam tube rotary dryer[33]

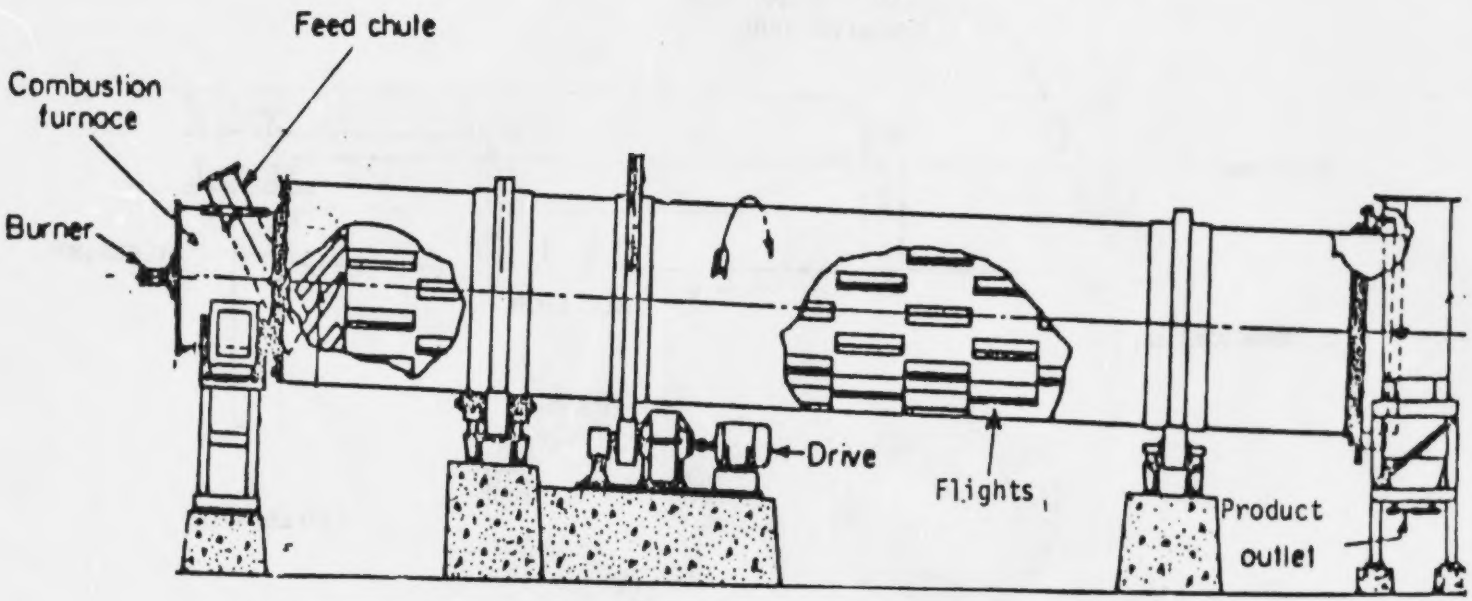
Feed chute
Combustion furnace
Burner
Drive
Flights
Product outlet

Figure 3-9. Direct fired, cocurrent, rotary dryer.[34]

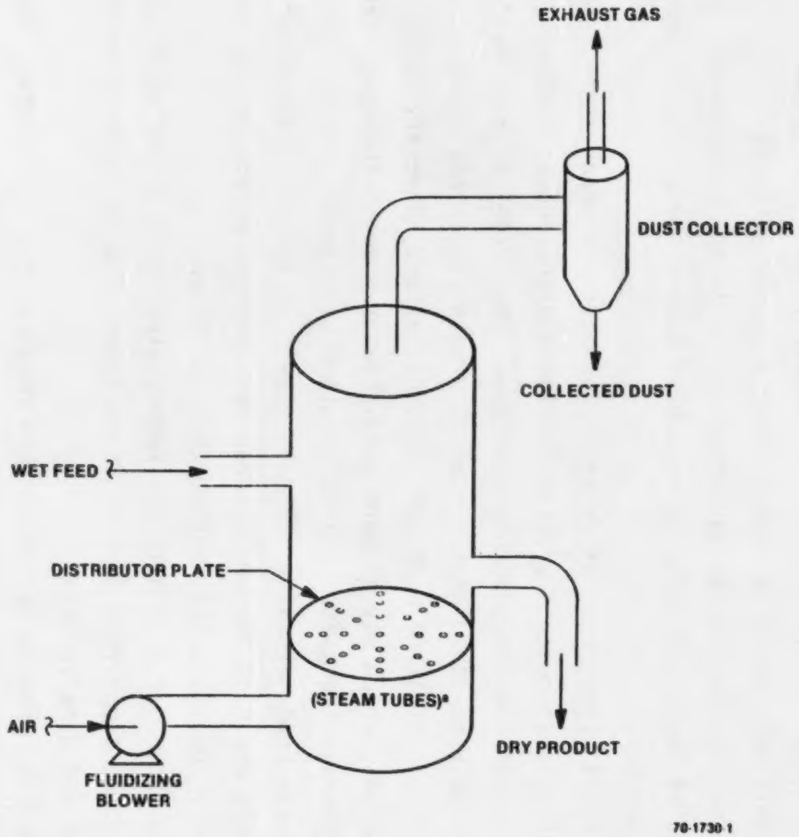
EXHAUST GAS
DUST COLLECTOR
COLLECTED DUST
WET FEED
DISTRIBUTOR PLATE
(STEAM TUBES)a
DRY PRODUCT
AIR
FLUIDIZING BLOWER
70-1730-1

Figure 3-10. Fluidized-bed dryer.[35]

[a] The "steam tubes" are not necessarily tubular in shape. The actual configuration is not shown because of a confidentiality agreement with the manufacturer using fluid-bed dryers.

The wet feed is introduced continuously into one side of the fluidizing chamber. The continuous introduction of new material "pushes" the fluidized bed toward the opposite side of the fluidizing chamber. The dried solids are removed on this side, opposite from the point where feed is introduced. One of several techniques may be used to remove the dried solids. For nontoxic substances dried in an air stream (such as sodium carbonate) an overflow weir is normally used. The dried solids overflow this weir and then fall through a discharge chute.

Some solids are carried out of the dryer in the air stream. However, most of these are normally recovered before the air is discharged to the atmosphere.

3.2.2.1.4 Comparison of dryers. For both the monohydrate process and the direct carbonation process, drying and subsequent cooling are the last processing steps before shipping. Thus, coal or high sulfur oil cannot be used for direct firing of dryers since this would result in product contamination with coal ash and sulfur. However, these energy sources, which may be more available or cheaper than gas, can be used to generate steam for indirect heating of dryers.

Only one producer currently uses gas-fired dryers. Because of the short supply and high cost of natural gas, any new dryers in the industry will probably be steam tube rather than gas-fired.

Three producers currently use rotary steam tube dryers while one uses fluid bed steam tube dryers. Both types of dryer have relative advantages and disadvantages.

Generally, greater maintenance is required for rotary steam tube dryers than for fluid bed steam tube dryers. It is apparently difficult to prevent leakage around rotary seals, and good rotary units which use high pressure steam are reportedly difficult to obtain.[36] A significant disadvantage of fluid bed steam tube dryers over rotary steam tube dryers is that larger amounts of gas must be handled by the processing equipment and by the emission control equipment.

3.2.2.1.5 Size of dryers. The reported maximum operating capacities of dryers used in sodium carbonate plants range from approximately 23 to 113 Mg/h (25 to 130 TPH) of dry sodium carbonate product. Dryers in future plants are expected to have capacities of approximately 63 Mg/h (70 tph) of dry sodium carbonate product. This is the size dryer which would be required to produce 454,000 Mg/yr (500,000 TPY) of sodium carbonate, assuming an annual operating factor of 85 percent.

3.2.2.2. Emissions. Sodium carbonate fines are emitted from each of the three types of dryers used. Particulate emission factors, particulate concentrations, and exit gas flow factors from rotary and fluid-bed dryers and gas flow factors from gas-fired dryers measured during source tests are presented in Table 3-6. Estimated uncontrolled particulate emission rates, particulate concentrations, and exit gas flow rates for small and medium sized rotary dryers and for medium and large fluid bed dryers extrapolated from EPA test data are presented in Table 3-7. No data on uncontrolled particulate emission rates for gas-fired dryers are available.

Particle size distributions for rotary steam tube and fluid bed steam tube dryers are presented in Figure 3-11.

Particulate emissions from dryers are affected by the gas velocity and the particle size distribution of the feed. Gas velocity through the dryer affects the degree of turbulence and agitation. As the gas velocity increases, the rate of increase in the total emission rate of particulates steadily increases. (Not enough information is available to define the effect on particulate concentration.) Therefore, because of higher gas flow rates (and higher gas velocities), fluid bed steam tube dryers and rotary gas-fired dryers have higher emission rates than rotary steam tube dryers. Particle size distribution of the ore affects particulate emissions because small particles are more easily entrained in a moving stream of gas than are larger particles.

3.2.2.3 Mass and Energy Balances. Values for mass and energy balances on dryers in the monohydrate and direct carbonation processes are presented in Table 3-8. Factors for energy usage and exit gas flow per unit mass of product are presented along with exit gas temperature and moisture content and the mass ratio of monohydrate crystal feed to dry sodium carbonate product. The factor for exit gas flow was calculated by assuming a free water content of 10 percent in the dryer feed slurry

TABLE 3-6. UNCONTROLLED EMISSION PARAMETERS FOR DRYERS IN THE MONOHYDRATE AND DIRECT CARBONATION PROCESSES.

Source of Data	Dryer Type[a]	Dryer Size[b]	Particulate kg/Mg dry Product	Emission Factor lb/ton dry Product	Particulate g/dNm^3	Concentration gr/dscf	Exit Gas Flow Factor[c]	
							dNm^3/Mg dry product	dscf/ton dry product
EPA Test-Plant A[d]	ST	M	28.6	57.2	73.9	32.3	387	12,400
	ST	M	33.9	67.7	68.6	30.0	493	15,800
	ST	M	25.6	51.1	77.1	33.6	331	10,600
EPA Test-Plant B[e]	FB	L	116	231	90.8	39.7		
	FB	L	52.5	105	44.2	19.3	1340	43,000
	FB	L	51.5	103	41.9	18.3		
Industry Data-Plant A[f]	ST	M	–	–	–	–	412-562	13,100-18,000
Industry Data-Plant A (Avg.)	ST	M	–	–	–	–	509	16,300
Industry Data-Plant B	FB	M	–	–	–	–	1250	40,000
Industry Data-Plant B (Avg.)	FB	L	–	–	–	–	855	27,400
Industry Data-Plant C	ST	S	–	–	–	–	285-581	9120-18,600
Industry Data-Plant C (Avg.)	ST	S	–	–	–	–	418	13,400
Industry Data-Plant D	GF	M	–	–	–	–	1350-1790	43,300-57,400
Industry Data-Plant D	GF	L	–	–	–	–	568-659	18,200-21,100
Industry Data-Plant D (Avg.)	GF		–	–	–	–	1250	40,100

[a] ST = rotary steam tube, FB = fluid bed steam tube; GF = Gas-fired rotary.

[b] S = Small, 20-30 Mg/hr
M = Medium, 50-70 Mg/hr
L = Large, 90-130 Mg/hr

[c] Flow rate is at exit of scrubber.

[d] Reference 37.

[e] Reference 38.

[f] Reference 39.

TABLE 3-7. UNCONTROLLED PARTICULATE EMISSIONS FROM DRYERS IN THE MONOHYDRATE AND DIRECT CARBONATION PROCESSES (EXTRAPOLATED FROM EPA TEST DATA)[a]

Dryer Type	Size	Production Rate (Dry Product) Mg/hr (tph)	Particulate Emission Factor kg/Mg (lb/ton)	Particulate Emission Rate[b] kg/hr (lb/hr)	Particulate Concentration g/dNm^3 (gr/dscf)	Exit Gas Flow Rate[b] dNm^3/min (dscf/min)
Rotary Steam Tube	Small	23 (25)	25.6 - 33.9 (51.1 - 67.7)	581 - 767 (1280 - 1690)	69 - 77 (30 - 34)	125 - 186 (4420 - 6580)
Rotary Steam Tube	Medium	63 (70)	25.6 - 33.9 (51.1 - 67.7)	1620 - 2150 (3500 - 4740)	69 - 77 (30 - 34)	351 - 521 (12,400 - 18,400)
Fluid Bed Steam Tube	Medium	63 (70)	51.5 - 116 (103 - 231)	3270 - 7350 (7210 - 16,200)	42 - 91 (18 - 40)	∼1420 (∼50,200)
Fluid Bed Steam Tube	Large	113 (130)	51.5 - 116 (103 - 231)	6080 - 13,600 (13,400 - 30,000)	42 - 91 (18 - 40)	∼2600 (∼94,500

[a] Reference 40,41.

[b] Particulate emission rate and exit gas flow rate were calculated by ratioing values measured in source tests according to production rate.

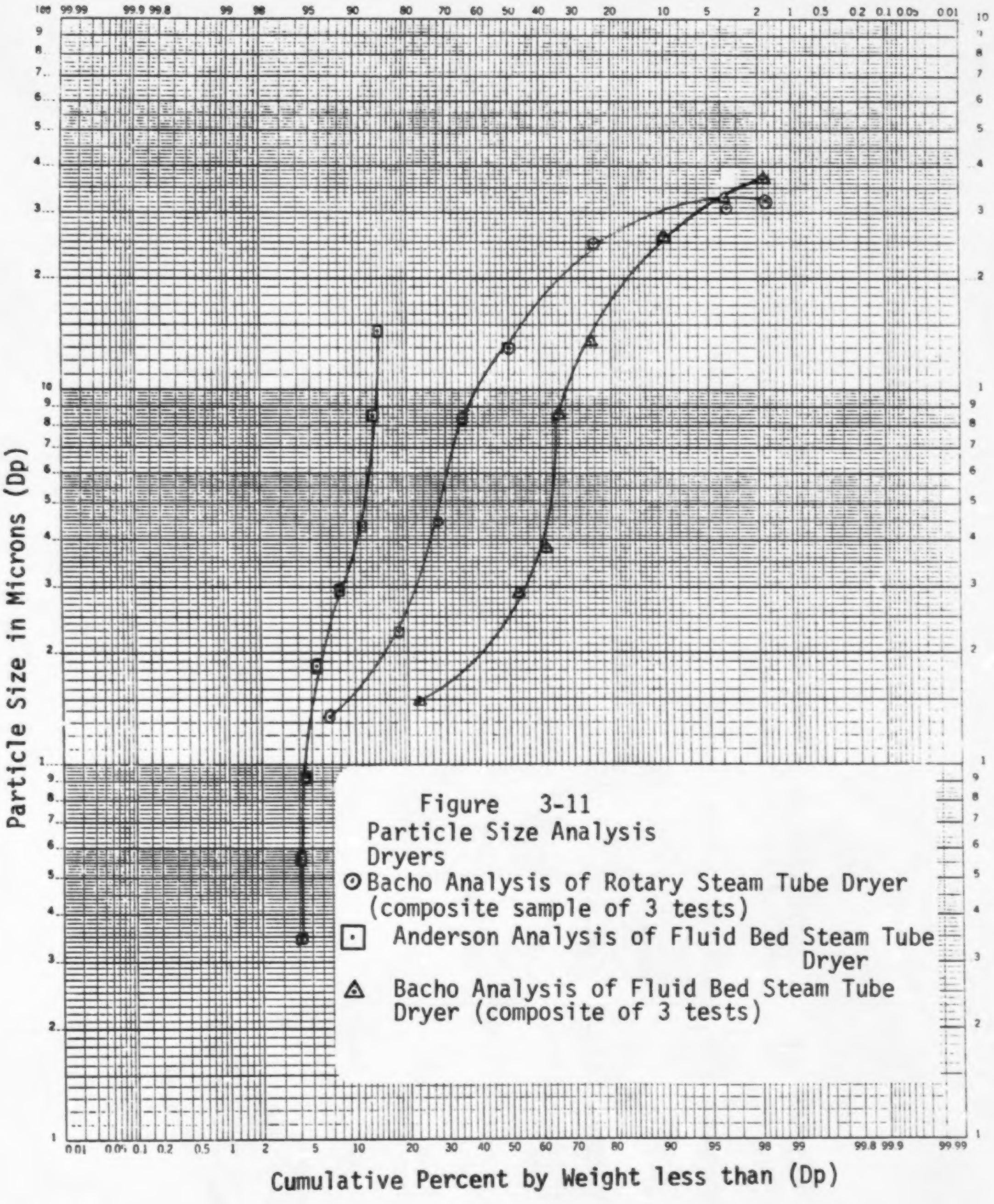

Figure 3-11
Particle Size Analysis
Dryers

TABLE 3-8. VALUES FOR MASS AND ENERGY BALANCES ON DRYERS IN THE MONOHYDRATE AND DIRECT CARBONATION PROCESSES

Dryer Type	Energy Usage Factor[a] J/Mg Dry Product (Btu/ton Dry Product)	Exit Gas Flow Rate Factor dNm^3/Mg Dry Product (dscf/ton Dry Product)	Exit Gas Temperature °C (°F)	Exit Gas Moisture Content Vol.%	Mg of Dry Monohydrate Crystal Feed[b] / Mg of Final Sodium Carbonate Product
Rotary Steam Tube	$7.3 \times 10^8 - 2.5 \times 10^9$[c] $(6.3 \times 10^5 - 8.4 \times 10^5)$	587 (1.88×10^4)	88[d] (190)	40[e]	1.17
Fluid Bed Steam Tube	$8.1 \times 10^8 - 1.1 \times 10^9$[c] $(6.9 \times 10^5 - 9.2 \times 10^5)$	1340[f] (4.3×10^4)	120[f] (250)	20-30 20-30	1.17
Rotary Gas-fired	1.9×10^9[g] (1.6×10^6)	h	155 (310)	20-30	1.17

[a] The energy usage factor for steam tube equipment does not take into account the efficiency of steam generation. The energy usage factors for gas fired equipment is that which would be supplied by the gross heating value of the fuel.

[b] Assuming that all available Na_2CO_3 in the dryer feed is recovered as final product.

[c] Based on mass and energy balances assuming a range in free water content of the feed of 5-15%.

[d] Based on measurement during source tests. (Reference 43.)

[e] Based on dryer design data.[44] Source test data indicate 60%.[43]

[f] Based on source test data. (Reference 45.)

[g] Based on values calculated from a 1977 State Emission Inventory. (Reference 46.)

[h] Not reported due to inconsistensies in the raw data.

[i] Based on values reported in industry source test data (Reference 47).

and an outlet gas moisture content of 40 percent. (Design data for dryers at one plant specify an outlet moisture content of 30 to 50 percent.)[42] The bases for the other factors in the table are given in table footnotes.

Energy usage rates, material flow rates, and exit gas flow rates for rotary steam tube, fluid bed steam tube, and rotary gas-fired dryers producing 64 Mg/h (70 TPH) sodium carbonate are shown in Figure 3-12.

3.2.3 Predryers

3.2.3.1 General. In the direct carbonation process, rotary steam heated predryers are used to lower the water content of wet sodium bicarbonate crystals before they are calcined. The fact that predryers do not dry the bicarbonate crystals to complete dryness is one of the significant differences between predryers and dryers. Other significant differences are in the physical construction and the operating conditions of the equipment.

Predryers consist essentially of a rotating metal cylinder elevated at the feed end to facilitate the flow of wet sodium bicarbonate toward the discharge end. Ambient air preheated in steam tube heat exchangers is admitted at the elevated end of the predryers. The air flows in a cocurrent direction relative to the flow of the sodium bicarbonate. This hot air transfers heat to the solids by convection, and as the cooled air exhausts from the predryers, it carries out evaporated water. Lifting flights along the inside of the predryers provide intimate mixing between the wet sodium bicarbonate and the drying air.

Dissociation of sodium bicarbonate to sodium carbonate, carbon dioxide, and water begins at about 50°C (120°F), and increases with increasing temperature.[48] The predryers are not designed for carbon dioxide recovery; however, the calciners immediately downstream of the predryers are designed for carbon dioxide recovery. (The carbon dioxide recovered in the calciners is recycled to the brine carbonators.) Thus, to avoid the loss of significant quantitites of carbon dioxide in the predryers, they are operated at relatively low temperatures.

Quantitative values for the operating parameters and the emissions for predryers are presented in Sections 3.2.3.2 and 3.2.3.3. These

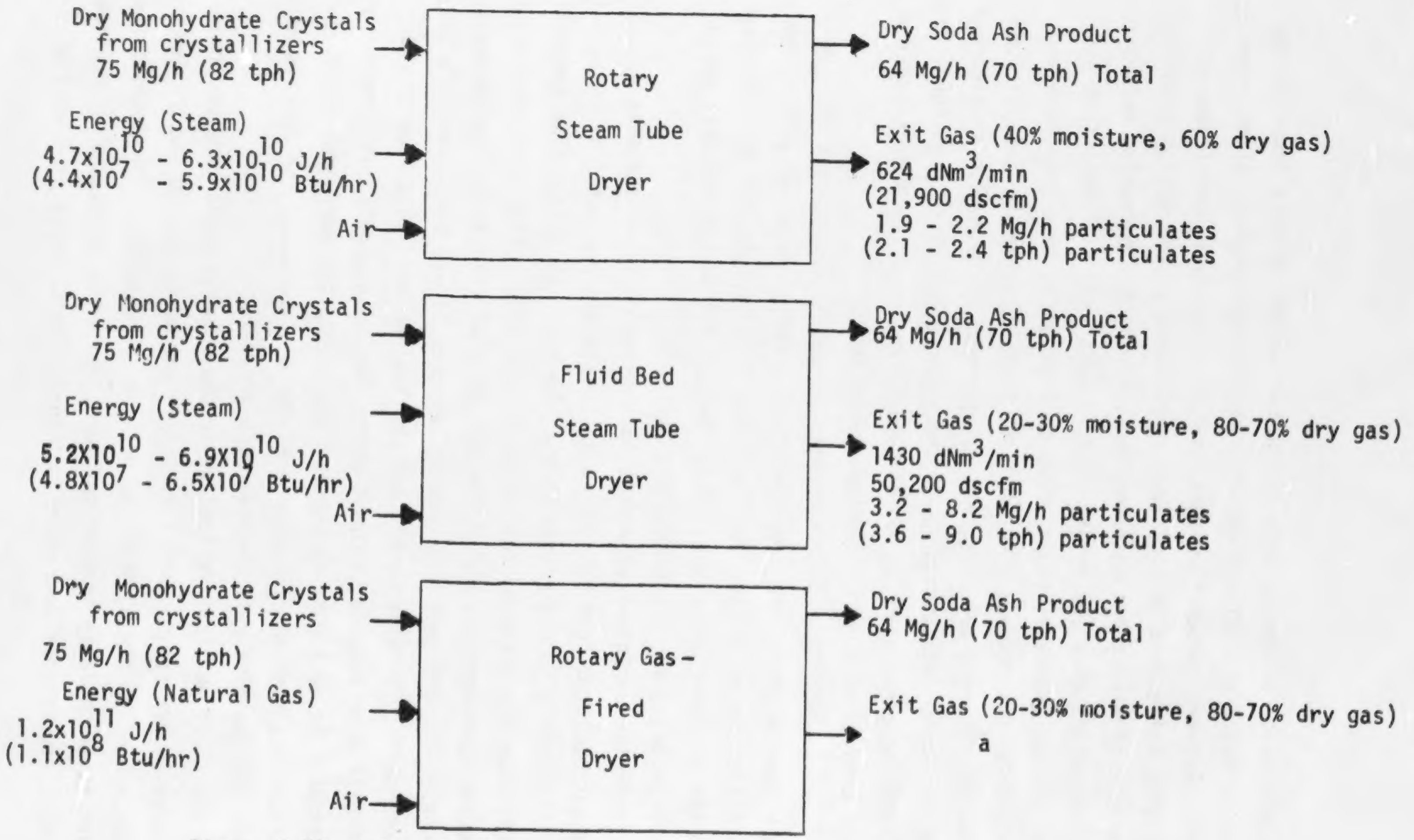
Dry Monohydrate Crystals from crystallizers 75 Mg/h (82 tph)
Energy (Steam) 4.7x10^10 - 6.3x10^10 J/h (4.4x10^7 - 5.9x10^10 Btu/hr)
Air
Rotary Steam Tube Dryer
Dry Soda Ash Product 64 Mg/h (70 tph) Total
Exit Gas (40% moisture, 60% dry gas) 624 dNm^3/min (21,900 dscfm) 1.9 - 2.2 Mg/h particulates (2.1 - 2.4 tph) particulates
Dry Monohydrate Crystals from crystallizers 75 Mg/h (82 tph)
Energy (Steam) 5.2X10^10 - 6.9X10^10 J/h (4.8X10^7 - 6.5X10^7 Btu/hr)
Air
Fluid Bed Steam Tube Dryer
Dry Soda Ash Product 64 Mg/h (70 tph) Total
Exit Gas (20-30% moisture, 80-70% dry gas) 1430 dNm^3/min 50,200 dscfm 3.2 - 8.2 Mg/h particulates (3.6 - 9.0 tph) particulates
Dry Monohydrate Crystals from crystallizers 75 Mg/h (82 tph)
Energy (Natural Gas) 1.2x10^11 J/h (1.1x10^8 Btu/hr)
Air
Rotary Gas-Fired Dryer
Dry Soda Ash Product 64 Mg/h (70 tph) Total
Exit Gas (20-30% moisture, 80-70% dry gas) a

Figure 3-12. Material flow rates and energy usage rates for a dryer in a plant using the monohydrate process

[a] Insufficient information.

values are based on design data and actual operating data taken during EPA source tests at a direct carbonation sodium carbonate plant recently brought on-stream. Operating personnel at this plant have found it technically infeasible to operate the predryers at the design conditions for certain of the operating parameters. Thus, the operating values for these parameters observed during source tests were different from the design values. However, plant personnel indicated that the operating conditions of the predryers had not yet been optimized. Thus, at some time in the future plant personnel may perform optimization studies and change the operating conditions of the predryers. If this is done, the new operating conditions may be different from both the design conditions and the conditions observed during source tests.

3.2.3.2 Emissions. Particulates of sodium bicarbonate are the primary type of emissions from predryers. Particulate emission factors, particulate concentrations, and exit gas flow factors for predryers are presented in Table 3-9. Both design values and values measured during EPA source tests are presented in this table.

Estimated uncontrolled particulate emission rates and exit gas flow rates extrapolated from EPA source test data are presented in Table 3-10 for a predryer with a dry feed rate of 59 Mg/h (65 TPH). (Two predryers of this size are expected for direct carbonation sodium carbonate plants producing approximately 454,000 Mg/yr (500,000 TPY) of sodium carbonate product.) The EPA test data are believed to be the best available data for estimating normal uncontrolled particulate emissions even though these data were taken at a plant where operating conditions were not yet optimized. As mentioned in Section 3.2.3.1, plant personnel found it technically infeasible to operate at the design values for certain parameter; the gas flow rate was one such parameter.

The lower particulate loading in the exhaust gases from predryers relative to dryers (Section 3.2.2.2) is partially due to the difference in the amount of drying which is done in these units. The product from dryers is essentially free of moisture, while the product from predryers contains significant amounts of moisture. Thus, there is a zone of dry

TABLE 3-9. UNCONTROLLED EMISSION PARAMETERS FOR PREDRYERS IN THE DIRECT CARBONATION PROCESS

Source of Data	Particulate Emission Factor		Particulate Concentration		Exit Gas Flow Factor	
	kg/Mg dry feed[a]	lb/ton dry feed[a]	g/dNm^3	gr/dscf	dNm^3/Mg dry feed[a,b]	dscf/ton dry feed[a,b]
EPA Test Data[c]	1.12	2.24	0.620	0.271	1800	57800
	0.499	0.998	0.281	0.123	1770	56800
EPA Test Data[c]	0.419	0.838	0.261	0.114	1610	51500
	0.855	1.71	0.483	0.211	1770	56800
	3.15	6.29	1.49	0.653	2110	67400
	3.21	6.42	1.43	0.625	2240	71900
Design Data[d]	27	55	10	4.4	2700	86000

[a] Values are reported in terms of pure dry feed as sodium bicarbonate. Approximate free water content and impurity content of the sodium bicarbonate feed are reported in Table 3-11.

[b] During the time that the EPA test data were obtained, plant operators were not varying the gas flow rate even though the feed rate of bicarbonate crystals was variable. The differences in the exit gas flow factors obtained from EPA test data are due primarily to differences in the feed rate of bicarbonate crystals rather than differences in the gas flow rate.

[c] Reference 49

[d] Reference 50

TABLE 3-10. UNCONTROLLED PARTICULATE EMISSIONS FROM PREDRYERS IN THE DIRECT CARBONATION PROCESS

(Extrapolated from EPA Test Data)[a]

Feed Rate[b] Mg/h (TPH)	Particulate Emission Factor[b] kg/Mg feed (lb/ton feed)	Particulate Emission Rate kg/h (lb/h)	Particulate Concentration g/dNm^3 (gr/dscf)	Exit Gas Flow Rate d/Nm^3/min (dscf/min)
59	0.377-3.21	22.2 - 189	0.261 -1.49	1400-2400
(65)	(0.754-6.42)	(49.0 - 417)	(0.114-0.653)	(46000-78000)

[a] Reference 51

[b] Reported as dry impure sodium bicarbonate feed. The impurity content ranges from 0 to 10%.

material near the discharge end of dryers; however, the material throughout predryers is moist. Moisture increases the surface tension between crystals, and this increased surface tension suppresses dusting.

Particulate emissions from predryers are affected by gas velocity and the particle size distribution of the feed. Gas velocity through the predryer affects the degree of turbulence and agitation. As the gas velocity increases, the rate of increase in the total emission rate of particulates increases. (Not enough information is available to define the effect on particulate concentration). Particle size distribution of the feed affects particulate emissions because small particles are more easily entrained in a moving stream of gas than are larger particles.

Particle size distribution of emissions from predryers measured in EPA source tests are presented in Figure 3-13.

3.2.3.3 Mass and Energy Balances. Values for mass and energy balances on predryers are presented in Table 3-11. In most cases, a range which includes design values and values obtained or calculated from data taken during EPA source tests is reported. The range of values reported for the exit gas flow factor is based on EPA source test data only, since, as discussed in Section 3.2.3.2, these data are believed to be more representative than design data of how predryers will normally operate.

Energy usage rate, material flow rates, and exit gas flow rate for a predryer with a capacity of 59 Mg/hr (65 TPH) of dry bicarbonate feed are indicated in Figure 3-14. Values indicated in Figure 3-14 are based on values presented in Table 3-11.

3.2.4 Bleachers

3.2.4.1 General. In the direct carbonation process, impure sodium carbonate from the calciners is bleached with sodium nitrate to burn off discoloring impurities. These impurities consist mostly of carbonaceous organics.

The bleaching operation is carried out in a rotary gas-fired unit similar to the gas-fired dryer described in Section 3.2.2.1.2 and pictured in Figure 3-9. Feed is introduced at the elevated end and flows countercurrently to the hot combustion gases. Lifting flights along the

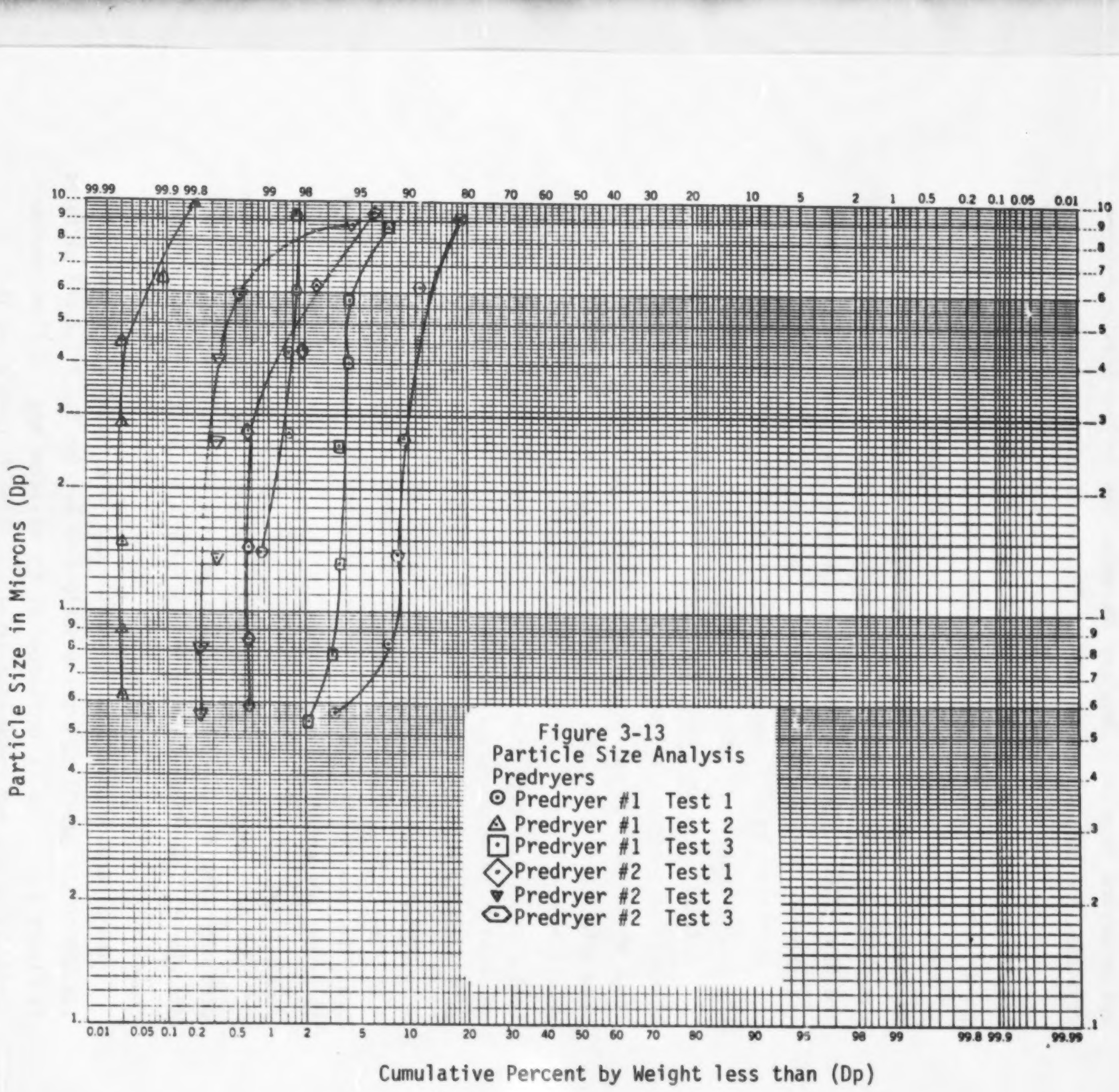

Figure 3-13
Particle Size Analysis
Predryers

TABLE 3-11. VALUES FOR MASS AND ENERGY BALANCES ON PREDRYERS

Parameter	Value
Energy Usage Factor[a,b,c]	
J/Mg Dry Feed	$1.5 \times 10^8 - 5.8 \times 10^8$
(Btu/Ton Dry Feed)	$1.3 \times 10^5 - 5.1 \times 10^5$
Exit Gas Flow Factor [c,d]	
dNm^3/Mg Dry Feed	$1.4 \times 10^3 - 2.4 \times 10^3$
(dsef/Ton Dry Feed)	$(4.2 \times 10^4 - 7.2 \times 10^4)$
Exit Gas Moisture Content[a]	
Vol %	4 - 10
Exit Gas Temperature[a]	
°C	38 - 57
(°F)	(100 - 135)
Moisture Content of Bicarbonate Crystal Feed[a,f]	
%	6 - 16
Moisture Content of Bicarbonate Crystals from the Predryer[a,f]	
%	5 - 15
$\frac{\text{Mg of Dry Bicarbonate Crystal Feed}^{c,e}}{\text{Mg of Final Sodium Carbonate Product}}$	1.8 - 2.0
Impurity Content of the Bicarbonate Crystal Feed[g] %	<10

[a] The reported range includes design values and values obtained or calculated from data taken during EPA source tests.

[b] The energy usage factor does not take into account the efficiency of steam generation equipment.

[c] Based on impure dry feed as sodium bicarbonate.

[d] Based on values obtained during EPA source tests.

[e] Based on the assumption that 90 percent of the available sodium carbonate in the predryer feed is recovered as final sodium carbonate product.

[f] Wet basis

[g] Dry basis. The design value is within this range.

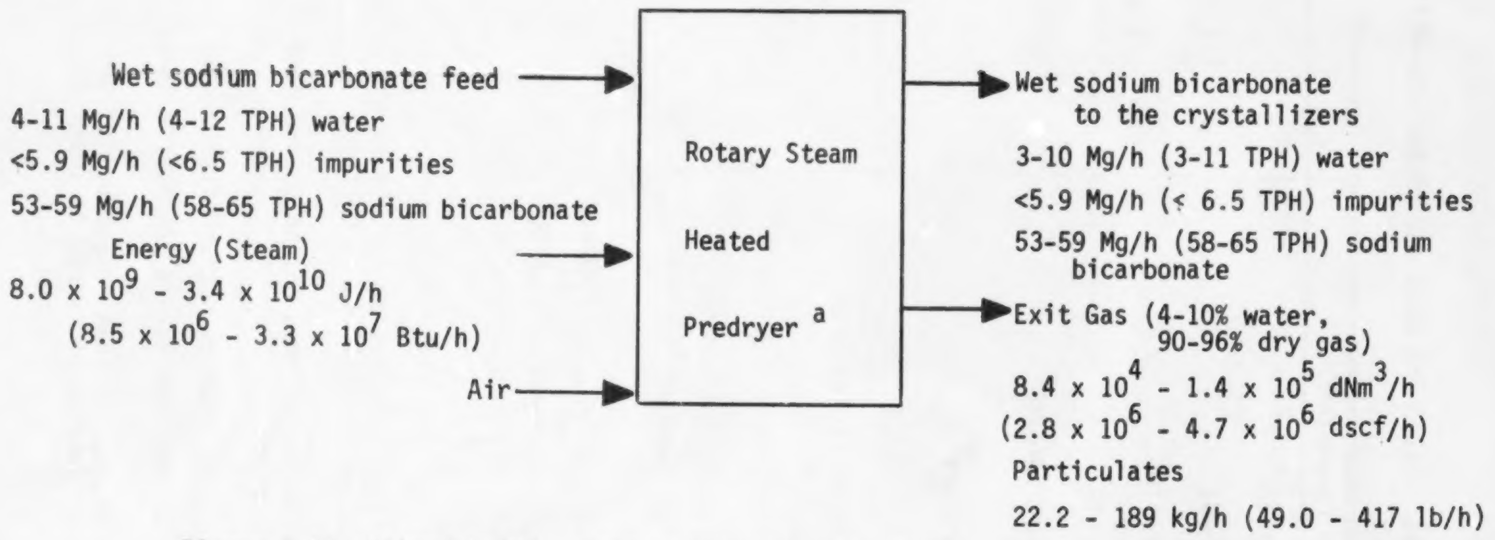
Wet sodium bicarbonate feed
4-11 Mg/h (4-12 TPH) water
<5.9 Mg/h (<6.5 TPH) impurities
53-59 Mg/h (58-65 TPH) sodium bicarbonate
Energy (Steam)
$8.0 \times 10^{9} - 3.4 \times 10^{10}$ J/h
($8.5 \times 10^{6} - 3.3 \times 10^{7}$ Btu/h)
Air
Rotary Steam
Heated
Predryer [a]
Wet sodium bicarbonate to the crystallizers
3-10 Mg/h (3-11 TPH) water
<5.9 Mg/h (≤ 6.5 TPH) impurities
53-59 Mg/h (58-65 TPH) sodium bicarbonate
Exit Gas (4-10% water, 90-96% dry gas)
$8.4 \times 10^{4} - 1.4 \times 10^{5}$ dNm^{3}/h
($2.8 \times 10^{6} - 4.7 \times 10^{6}$ dscf/h)
Particulates
22.2 - 189 kg/h (49.0 - 417 lb/h)

Figure 3-14 Material flow rates and energy usage rates for predryers in a plant using the direct carbonation process.

[a] There are two predryers in a train.

inside of the bleacher aid the movement of the solids and provide intimate mixing with the combustion gases. The operating temperature of bleachers is reported to be approximately 450°C (850°F).

Quantitative values for other operating parameters and the emissions for bleachers are presented in Sections 3.2.4.2 and 3.2.4.3. These values are based on design data and actual operating data taken during EPA source tests at a direct carbonation sodium carbonate plant recently brought on-stream. The operating data taken during the source tests were in close agreement with the design values.

3.2.4.2 Emissions. Emissions from bleachers consist mainly of particulates of sodium carbonate. Small amounts of compounds formed from the reactions of sodium nitrate may also be present in the particulates.

Particulate emission factors, particulate concentrations, and exit gas flow factors for bleachers measured during EPA source tests are presented in Table 3-12. Design values are also presented. The design value for the particulate emission factor is lower than any of the values measured during the source tests. However, it is only slightly lower than the lowest measured value.

Particle size distributions for emissions from bleachers measured during EPA source tests are presented in Figure 3-15.

Estimated uncontrolled particulate emission rates and exit gas flow rates extrapolated from source test data are presented in Table 3-13 for a bleacher with a feed rate of 82 Mg/hr (90 TPH). (This size bleacher is expected for a direct carbonation plant producing approximately 454,000 Mg/yr (500,000 TPY) of sodium carbonate product.)

Particulate emissions from bleachers are affected by gas velocity and the particle size distribution of the feed. Gas velocity through the bleacher affects the degree of turbulence and agitation. As the gas velocity increase, the rate of increase in the total emission rate of particulates increases. (Not enough information is available to define the effect on particulate concentration.) Particle size distribution of the feed affects particulate emissions because small particles are more easily entrained in a moving stream of gas than are larger particles.

TABLE 3-12. UNCONTROLLED EMISSION PARAMETERS FOR BLEACHERS IN THE DIRECT CARBONATION PROCESS

Source of Data	Particulate Emission Factor		Particulate Concentration		Exit Gas Flow Factor	
	kg/Mg dry[a] feed	lb/ton dry[a] feed	g/dNm^3	gr/dscf	dNm^3/Mg dry feed	dscf/ton dry feed
EPA Test Data[b]	228	455	380	166	598	19200
	161	321	297	130	536	17200
	185	369	307	134	601	19300
EPA Test Data[b]	-	-	-	-	-	-
	152	303	277	121	548	17600
	53.5	106	105	46	508	16300
Design Data	34.5	68.9	70	30	512	16400

[a] Values were measured and are reported in terms of dry, pure feed as sodium carbonate, to the predryers. A one hour process lag time between the predryer feed point and the bleacher feed point was assumed. The actual feed to the bleachers is impure sodium carbonate with an impurity content of less than 15 percent.

[b] Reference 52

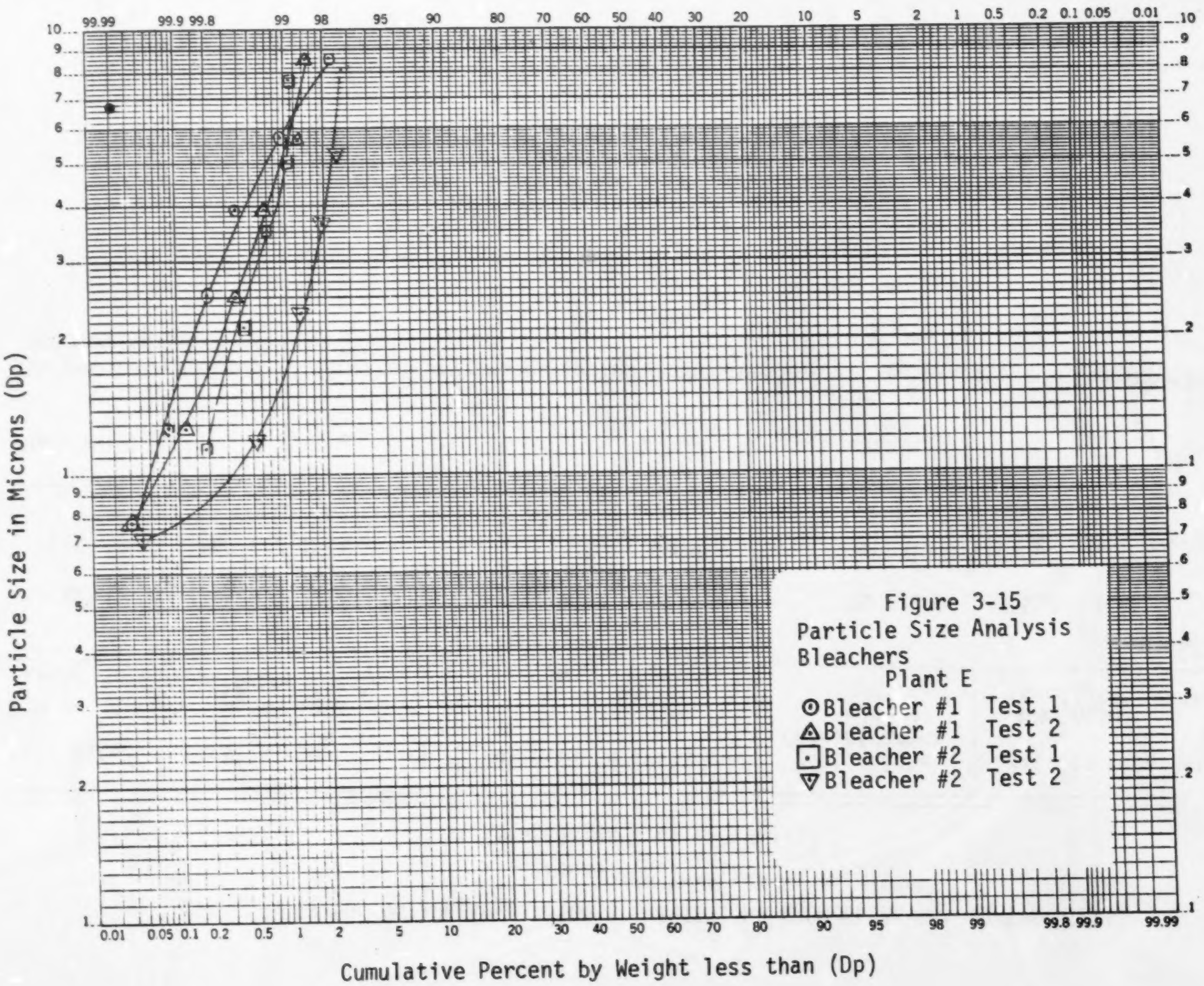

Figure 3-15
Particle Size Analysis
Bleachers
Plant E

⊙Bleacher #1 Test 1
△Bleacher #1 Test 2
⊡Bleacher #2 Test 1
▽Bleacher #2 Test 2

TABLE 3-13. UNCONTROLLED PARTICULATE EMISSIONS FROM BLEACHERS IN THE DIRECT CARBONATION PROCESS

(Extrapolated from EPA data)[a]

Feed Rate[b] Mg/h (ton/h)	Particulate Emission Factor[b] kg/Mg feed (lb/ton feed)	Particulate Emission Rate kg/h (lb/h)	Particulate Concentration g/dNm^3 (g/dscf)	Exit Gas Flow Rate dNm^3/min (dscf/min)
82	45.5 - 228	3700 - 19000	105 - 380	590 - 820
(90)	(90.1 - 455)	(8100 - 41000)	(46 - 166)	(21000 - 29000)

[a] Reference 53

[b] Values are reported in terms of dry impure sodium carbonate feed to the bleachers. The impurity content ranges from 0 to 15%.

The exit gas flow rate for bleachers is lower than that for gas-fired calciners or gas-fired dryers. This lower flow rate results from a lower energy requirement.

Sensible heat is the only significant energy requirement in the bleaching operation. However, in calcining and drying the sensible heat requirement is minor relative to the energy required to drive the endothermic reactions in these operations. Since the sensible heat requirement in bleaching is only about twice as great as the sensible heat requirement in either calcining or drying, the total energy requirements for bleaching are less than they are for either calcining or drying. Since less fuel is required, less combustion gas is generated.

3.2.4.3 Mass and Energy Balances. Values for mass and energy balances on bleachers are presented in Table 3-14. In most cases, a range which includes design values and values obtained or calculated from data taken during EPA source tests is reported. As discussed briefly in Section 3.2.4, there was generally close agreement between the design values and the values based on actual data taken during source tests.

Energy usage rate, material flow rates, and exit gas flow rate for a bleacher with a capacity of 85 Mg/h (90 TPH) of feed are presented in Figure 3-16. Values indicated in Figure 3-16 are based on values presented in Table 3-14.

3.3 BASELINE EMISSIONS

As noted in Section 3.1, all plants producing sodium carbonate by the monohydrate process are located in Wyoming and all direct carbonation plants are in California. All future plants are also expected to be located in these states. Thus, the emission regulations of these two states will be used to define the baseline emission level in this study for these respective plants.

Several regulations limiting particulate emission rates are applicable to sodium carbonate plants in Wyoming. The maximum emission rate that would be allowed by the Wyoming Department of Environmental Quality is given by a process weight regulation, as follows:

TABLE 3-14. VALUES FOR MASS AND ENERGY BALANCES ON BLEACHERS

Parameter	Value
Energy Usage Factor[a,b,c]	
J/Mg Feed	$4 \times 10^8 - 5 \times 10^8$
(Btu/ton Feed)	$3 \times 10^5 - 4 \times 10^5$
Exit Gas Flow Factor[c,d]	
dNm^3/Mg Feed	430 - 600
(dscf/ton Feed)	$1.4 \times 10^4 - 1.9 \times 10^4$
Exit Gas Moisture Content[a]	
Vol %	4 - 8
Exit Gas Temperature[a]	
°C	163 - 204
(°F)	(325 - 400)
Mg of Feed[c,e] / Mg of Final Sodium Carbonate Product	1.1 - 1.3
Impurity Content of the Feed	<15

[a] The reported range includes design values and values obtained or calculated from data taken during EPA source tests.

[b] The energy usage factors represent the energy which must be supplied by the gross heating value of the fuel.

[c] Based on impure dry feed as sodium carbonate.

[d] Based on values obtained during EPA source tests.

[e] Based on the assumption that 90 percent of the available sodium carbonate in the bleacher feed is recovered as final sodium carbonate product.

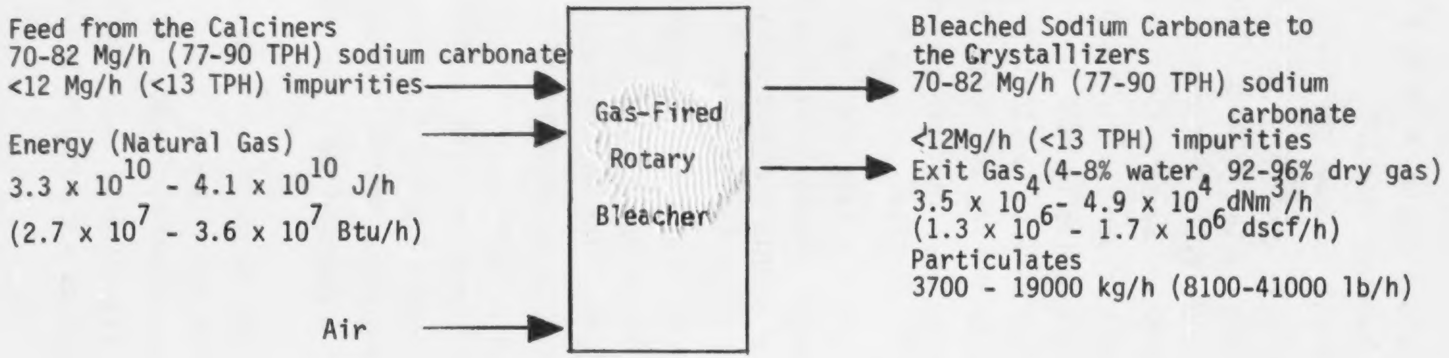
Feed from the Calciners
70-82 Mg/h (77-90 TPH) sodium carbonate
<12 Mg/h (<13 TPH) impurities
Energy (Natural Gas)
$3.3 \times 10^{10} - 4.1 \times 10^{10}$ J/h
($2.7 \times 10^{7} - 3.6 \times 10^{7}$ Btu/h)
Air
Gas-Fired Rotary Bleacher
Bleached Sodium Carbonate to the Crystallizers
70-82 Mg/h (77-90 TPH) sodium carbonate
<12Mg/h (<13 TPH) impurities
Exit Gas (4-8% water, 92-96% dry gas)
$3.5 \times 10^{4} - 4.9 \times 10^{4}$ dNm^3/h
($1.3 \times 10^{6} - 1.7 \times 10^{6}$ dscf/h)
Particulates
3700 - 19000 kg/h (8100-41000 lb/h)

Figure 3-16 Material flow rates for a bleacher in a plant using the direct carbonation process.

$$\text{Allowable particulate emissions (lb/hr)} = 17.31\ X^{0.16}$$

$$\text{Where } X = \text{Process weight (tons per hour).}$$[54]

For coal-fired calciners, process weight includes the coal. This equation would be applied to each unit of process equipment.

However, a majority of the sources in the Wyoming sodium carbonate plants are controlled to more stringent levels than required by this process weight regulation. Under proposed Wyoming SIP revisions, the use of "BACT" is required for approval of permits for new plants and expansions. The emission level corresponding to BACT is determined by the State of Wyoming on a case by case basis. For large sources (such as calciners) it is generally close to the process weight limitation, but for smaller sources (such as dryers) the BACT requirement is generally more stringent than process weight.[55] This strict level is imposed to achieve and maintain an ambient particulate standard of 60 $\mu g/m^3$. The area where three of the four sodium carbonate plants in Wyoming are located has been found to be in non-compliance with this standard and with the National Ambient Air Quality Standards for Particulates.[56]

Wyoming BACT levels are not set by law, but are determined on a case by case basis. Therefore, new plants may be subjected to a less stringent definition of BACT than existing plants. The most representative baseline emission level for this study would be in between the level based on the process weight regulation and the BACT level as defined for the most recently constructed plant. The level based on the process weight regulation will be used to analyze the control costs and economic impact of the regulatory alternatives, since it will yield a higher incremental control cost than the BACT level. Both levels will be used to project a range of emission reduction due to the regulatory alternatives.

The direct carbonation plants are in the San Bernardino County Air Quality District of California, which recently separated from the South Coast Air Quality Management District (SCAQMD) and applies most of the SCAQMD regulations.[57] Under these regulations, sodium carbonate plants are subject to mass emission limitations according to process weight and to concentration limitations based on exit gas flow rate.[58] The allowable concentrations and mass emission rates are given in Tables 3-15 and 3-16. Since sodium carbonate plants must comply with both of these limitations, the more stringent of the two is considered as the baseline emission level for direct carbonation plants. For predryers, process weight gives the stricter emission limit, but for bleachers and product dryers, the concentration limit is more stringent.

Emission rates that would be allowed under the applicable regulations for each piece of equipment for the equipment sizes considered for a model sodium carbonate plant are presented in Table 3-17. These emission rates represent the baseline emission levels for this study.

TABLE 3-15. MAXIMUM ALLOWABLE PARTICULATE CONCENTRATIONS FOR CALIFORNIA[59]

Volume Discharged Calculated as Dry Gas At Standard Conditions		Maximum Concentration of Particulate Matter Allowed in Discharged Gas Calculated as Dry Gas at Standard Conditions		Volume Discharged Calculated as Dry Gas At Standard Conditions		Maximum Concentration of Particulate Matter Allowed in Discharged Gas Calculated as Dry Gas at Standard Conditions	
Cubic Meters Per Minute	Cubic Feet Per Minute	Milligrams Per Cubic Meter	Grains Per Cubic Foot	Cubic Meters Per Minute	Cubic Feet Per Minute	Milligrams Per Cubic Meter	Grains Per Cubic Foot
25 or less	883 or less	450	0.196	900	31780	118	0.0515
30	1059	420	.183	1000	35310	113	.0493
35	1236	397	.173	1100	38850	109	.0476
40	1413	377	.165	1200	42380	106	.0463
45	1589	361	.158	1300	45910	102	.0445
50	1766	347	.152	1400	49440	100	.0437
60	2119	324	.141	1500	52970	97	.0424
70	2472	306	.134	1750	61800	92	.0402
80	2825	291	.127	2000	70630	87	.0380
90	3178	279	.122	2250	79460	83	.0362
100	3531	267	.117	2500	88290	80	.0349
125	4414	246	.107	3000	105900	75	.0327
150	5297	230	.100	4000	141300	67	.0293
175	6180	217	.0947	5000	176600	62	.0271
200	7063	206	.0900	6000	211900	58	.0253
250	8829	190	.0830	8000	282500	52	.0227
300	10590	177	.0773	10000	353100	48	.0210
350	12360	167	.0730	15000	529700	41	.0179
400	14130	159	.0694	20000	706300	37	.0162
450	15890	152	.0664	25000	882900	34	.0148
500	17660	146	.0637	30000	1059000	32	.0140
600	21190	137	.0598	40000	1413000	28	.0122
700	24720	129	.0563	50000	1766000	26	.0114
800	28250	123	.0537	70000 or more	2472000 or more	23	.0100

TABLE 3-16. MAXIMUM ALLOWABLE SOLID PARTICULATE EMISSION RATES FOR CALIFORNIA[60]

Process Weight Per Hour		Maximum Discharge Rate Allowed for Solid Particulate Matter(Aggregate Discharged From All points of Process)		Process Weight Per Hour		Maximum Discharge Rate Allowed for Solid Particulate Matter(Aggregate Discharged From All points of Process)	
Kilograms Per Hour	Pounds Per Hour	Kilograms Per Hour	Pounds Per Hour	Kilograms Per Hour	Pounds Per Hour	Kilograms Per Hour	Pounds Per Hour
100 or less	220 or less	0.450	0.99	9000	19840	5.308	11.7
150	331	0.585	1.29	10000	22050	5.440	12.0
200	441	0.703	1.55	12500	27560	5.732	12.6
250	551	0.804	1.77	15000	33070	5.982	13.2
300	661	0.897	1.98	17500	38580	6.202	13.7
350	772	0.983	2.17	20000	44090	6.399	14.1
400	882	1.063	2.34	25000	55120	6.743	14.9
450	992	1.138	2.51	30000	66140	7.037	15.5
500	1102	1.209	2.67	35000	77160	7.296	16.1
600	1323	1.340	2.95	40000	88180	7.527	16.6
700	1543	1.461	3.22	45000	99210	7.738	17.1
800	1764	1.573	3.47	50000	110200	7.931	17.5
900	1984	1.678	3.70	60000	132300	8.277	18.2
1000	2205	1.777	3.92	70000	154300	8.582	18.9
1250	2756	2.003	4.42	80000	176400	8.854	19.5
1500	3307	2.206	4.86	90000	198400	9.102	20.1
1750	3858	2.392	5.27	100000	220500	9.329	20.6
2000	4409	2.563	5.65	125000	275600	9.830	21.7
2250	4960	2.723	6.00	150000	330700	10.26	22.6
2500	5512	2.874	6.34	175000	385800	10.64	23.5
2750	6063	3.016	6.65	200000	440900	10.97	24.2
3000	6614	3.151	6.95	225000	496000	11.28	24.9
3250	7165	3.280	7.23	250000	551200	11.56	25.5
3500	7716	3.404	7.50	275000	606300	11.82	26.1
4000	8818	3.637	8.02	300000	661400	12.07	26.6
4500	9921	3.855	8.50	325000	716500	12.30	27.1
5000	11020	4.059	8.95	350000	771600	12.51	27.6
6000	13230	4.434	9.78	400000	881800	12.91	28.5
7000	15430	4.775	10.5	450000	992100	13.27	29.3
8000	17640	5.089	11.2	500000 or more	1102000 or more	13.60	30.0

TABLE 3-17. BASELINE EMISSION LEVELS FOR MODEL SODIUM CARBONATE PLANTS

Facility	Feed Rate Mg/h (TPH)	Allowable Emission Rate[a] kg/h (lb/h)
Coal-fired Calciners	127 (140)[b]	9.2 (20.3)-17.3 (38.2)
Rotary Steam Tube Dryer	83 (91)[c]	4.7 (10.4)-15.9 (35.0)[d] 5.08 (11.2)[e]
Fluid Bed Steam Tube Dryer	83 (91)[c]	4.7 (10.4)-15.9 (35.0)
Predryer	59 (65)[f]	8.2 (18.2)
Bleacher	82 (90)	4.90 (10.8)

[a] Lower value represents BACT as defined for Tenneco plant; upper value represents process weight regulation.

[b] Includes 9 Mg/h (10 TPH) coal.

[c] Dry monohydrate crystals.

[d] For monohydrate process (Wyoming).

[e] For direct carbonation process (California).

[f] Dry weight.

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4. EMISSION CONTROL TECHNIQUES

Techniques suitable for controlling particulate emissions from calciners, dryers, predryers, and bleachers in sodium carbonate plants are discussed in this chapter. A general description of the applicable emission control techniques is given in Section 4.1, along with a discussion of significant design variables and factors affecting performance. Application of these control techniques to sources in the sodium carbonate industry is discussed in Section 4.2. The performances that have been demonstrated for each control device on sources in the sodium carbonate industry are presented in Section 4.3.

4.1 DESCRIPTION OF CONTROL TECHNIQUES

Particulate emission control techniques which may be applicable to sources in sodium carbonate plants include the following:

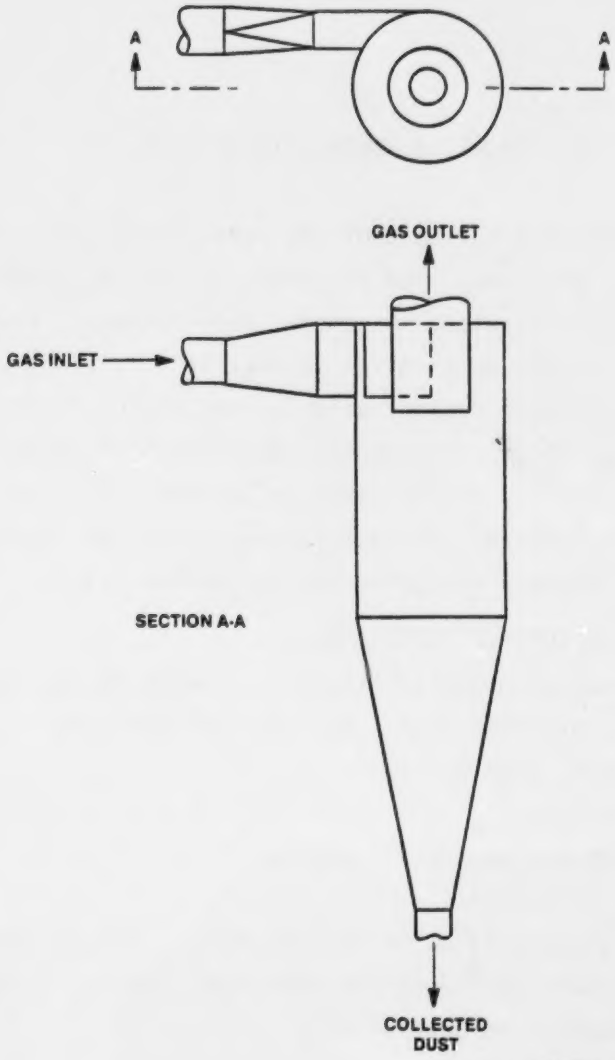
- centrifugal separation,
- wet scrubbing,
- electrostatic precipitation, and
- fabric filtration.

These techniques are described in this section. Factors affecting the applicability of these techniques to calciners, dryers, predryers, and bleachers are discussed in Section 4.2.

4.1.1 Centrifugal Separation

Centrifugal separators, or cyclones, rely on centrifugal forces to effect particulate separation from the gas stream. Cyclones are frequently used upstream of a scrubber or electrostatic precipitator.

4.1.1.1 Basic Description.[1] A typical cyclone is illustrated in Figure 4-1. Dust-laden gases enter a conical-shaped vessel tangentially or axially and leave through a central opening. As the gas flows in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A
GAS OUTLET
GAS INLET
SECTION A-A
COLLECTED DUST
70-1729-1

CYCLONE

Figure 4-1. Conventional centrifugal separator (cyclone)

a vortex down through the cyclone, the inertia of the particles causes them to move outward across the gas streamlines towards the cyclone shell. As the vortex is reversed in the conical portion of the cyclone, most of the particles continue to cyclone downward along the outer shell into a receiving chamber.

4.1.1.2 Factors Affecting Performance. The most important variables in the design of a cyclone are the cyclone dimensions. Small diameter cyclones have greater removal efficiencies and higher pressure drops due to the greater angular velocity (or inertia) of the gas stream and entrained particles. Banks of small-diameter cyclones in parallel, with common gas inlets and outlets, are frequently used to achieve higher efficiencies. Long cyclones have greater removal efficiencies than short cyclones due to the increased time in which particles are subject to separating forces. Cyclone pressure drops typically range from 5 to 15 cm (2 to 6 inches) of water.

Cyclone efficiency is highly dependent on the size of the particulates being collected: large particles are collected more efficiently. For example, a high efficiency cyclone may remove 95-99 percent of particles greater than 40u, 90-99 percent of particles from 15-50u, 80-90 percent of particles from 5-20u, and only 50-80 percent of particles less than 5u. Typical cyclone overall efficiencies range from about 55 to 95 percent.[1]

Various factors limit the effectiveness of cyclonic collectors. If the cyclone is designed for peak efficiency at peak flow, lower efficiencies will be achieved during lower flows due to the reduced gas velocity in the cyclone. Similarly, temperature decreases may reduce removal efficiency by increasing the viscosity and density of the gas. In-leakage of air through the dust removal system may reduce the overall collection efficiency by re-entraining dust. Additional re-entrainment can result if the dust is not adequately removed from the receiving chamber.

4.1.2 Wet Scrubbing

4.1.2.1 Basic Description[2] Scrubbers rely mainly on inertial impaction of particulates with water droplets to effect particulate separation from the gas stream. Parcles are contacted with a wetted surface or atomized liquid droplets. Although gas streams will diverge to pass such obstructions, the inertia of particles in the gas stream will carry the particles into the water droplets or wetted surface. The particulate laden liquid is then separated from the gas stream, and either recycled to the production process or discharged as waste.

Scrubbers are usually classified by energy consumption (in terms of gas-phase pressure drop). Low-energy scrubbers, represented by spray chambers and towers, have pressure drops less than 1.3 kPa (5" of water). Medium-energy scrubbers such as centrifugal scrubbers have pressure drops of 1.3-3.7 kPa (5-15" of water). High-energy scrubbers such as venturi scrubbers have pressure drops exceeding 3.7 kPa (15" of water). Because the efficiency of particle removal is largely proportional to the pressure drop, venturi scrubbers have been favored by sodium carbonate producers needing high removals of particulates.

A typical venturi scrubber is shown in Figure 4-2. Scrubbing liquid is injected into the gas stream and cascades by gravity and velocity pressures towards the venturi throat. In the high turbulence zone associated with the venturi throat, particulates collide with and are collected by the atomized liquid droplets. The liquid is subsequently separated from the gas in a cyclonic separator usually equipped with a mist eliminator. Higher scrubber pressure drops are achieved by narrowing the venturi throat.

4.1.2.2 Factors Affecting Performance. The design of a scrubber depends on the characteristics of the dust being collected and the gas being cleaned. The most important particle characteristics are particle size distribution, particulate loading, and physical and chemical properties of the particulate and gas.

Larger particles are removed more efficiently than small ones, as indicated in Figure 4-3. The principal factors affecting the performance of venturi scrubbers are the operating pressure drop across the scrubber,

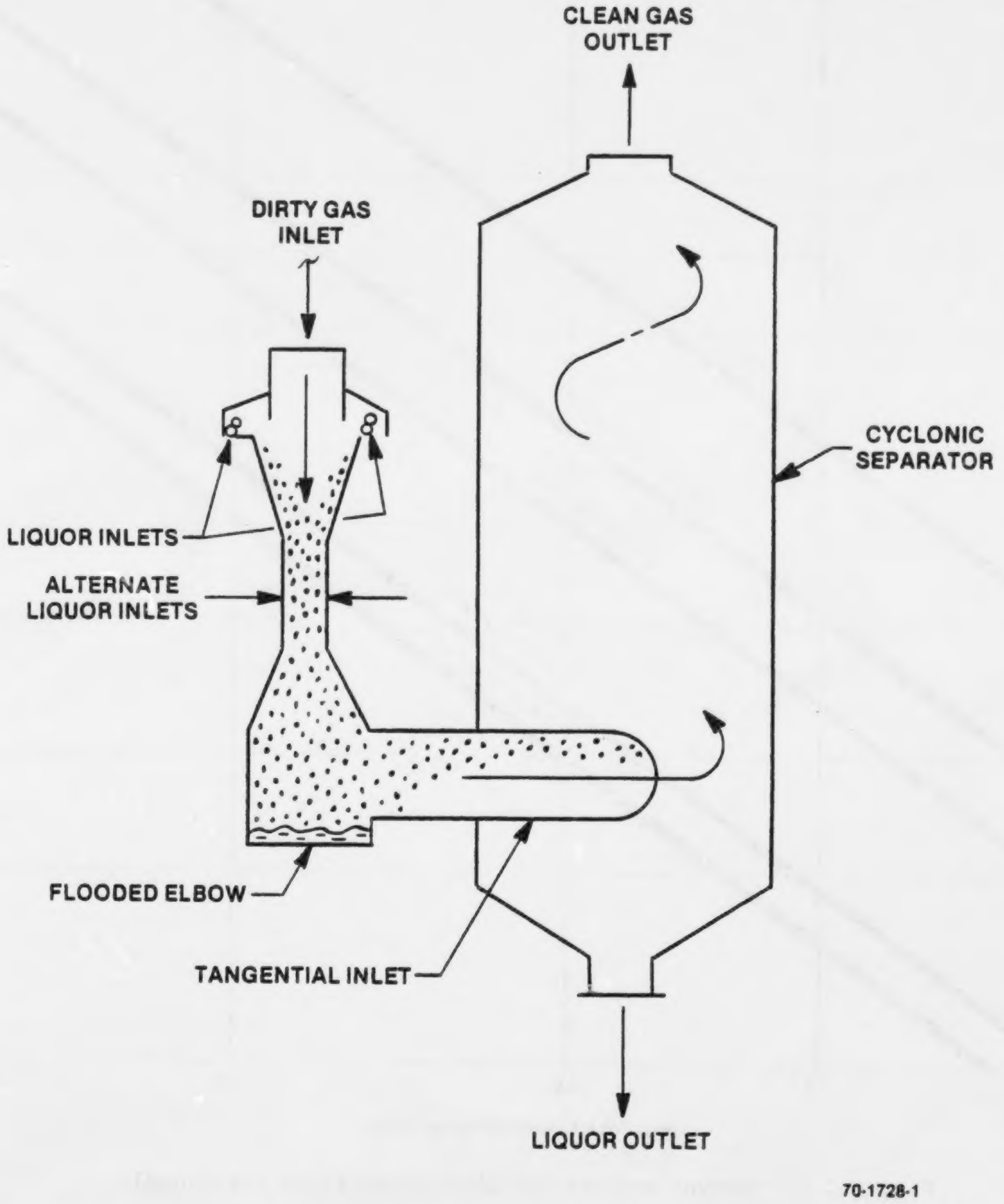
CLEAN GAS OUTLET
DIRTY GAS INLET
CYCLONIC SEPARATOR
LIQUOR INLETS
ALTERNATE LIQUOR INLETS
FLOODED ELBOW
TANGENTIAL INLET
LIQUOR OUTLET
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Figure 4-2. View of a venturi scrubber with centrifugal separator chamber

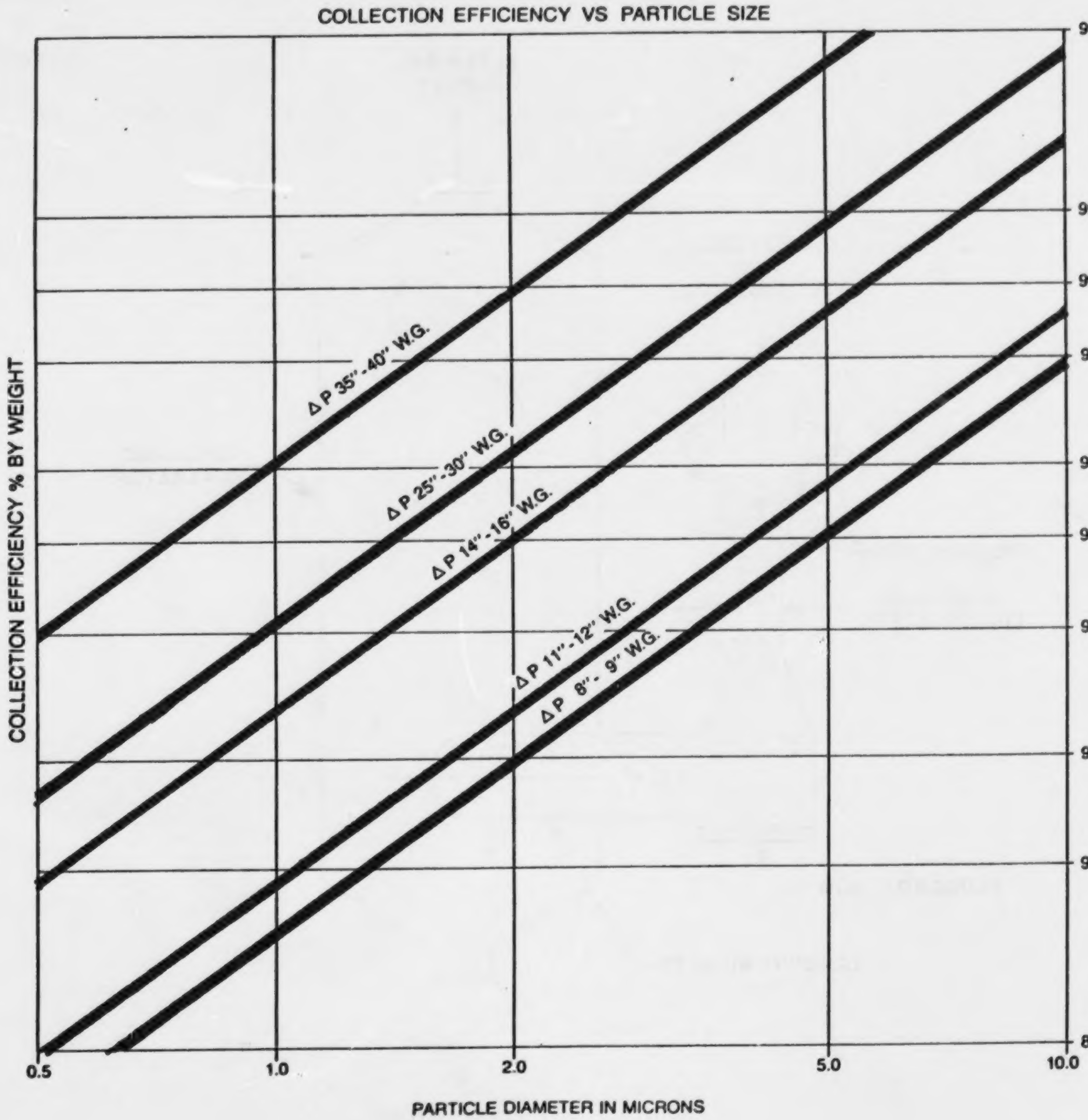

Figure 4-3. Vendor venturi scrubber comparative fractional efficiency curves.[3]

the liquid to gas ratio, the water/gas separation achieved in the separator, and the scrubber liquor saturation level. As shown in Figure 4-3, higher removal efficiencies are achieved with scrubbers operated at higher gas-phase pressure drops. Similarly, higher removals are achieved at higher liquid to gas ratios. However, there is a practical upper limit on these parameters, depending on the effectiveness of gas/liquid separation. Overall particulate removal efficiency is reduced if the downstream mist eliminator is unable to separate finely-atomized water droplets from the exit gas. These uncollected droplets evaporate and release their particulate contents to the air.

4.1.3 Electrostatic Precipitation[4,5]

4.1.3.1 Basic Description. The collection of particulates by electrostatic precipitation involves five basic steps:

- the generation of an electric field (or corona) around a high tension wire,
- the ionization of gas molecules by the corona,
- the charging of particulates by ionized gas molecules near the wire,
- the migration of the charged particulates to oppositely charged collecting electrodes, and
- the removal of the charged particles.

A typical electrostatic precipitator is pictured in Figure 4-4.

The corona is generated by the application of a high voltage to a discharge electrode system consisting of rows of vertical wires. The strength of the corona depends in part on the gas composition. The charging of particles depends on local conditions in the electrostatic precipitator (ESP) such as strength of the corona and on the characteristics of the particles. The subsequent migration of the charged particles to the collecting plates depends on the particle size, resistivity, gas velocity and distribution, rapping, and field strength.

The collecting electrodes are rigid plates that are baffled. Electromagnetic or pneumatic hammers are used to rap the electrodes, dislodging the collected dust which then falls into hoppers. Baffling on the collecting electrodes provides shielded air pockets that reduce re-entrainment of particles after rapping.

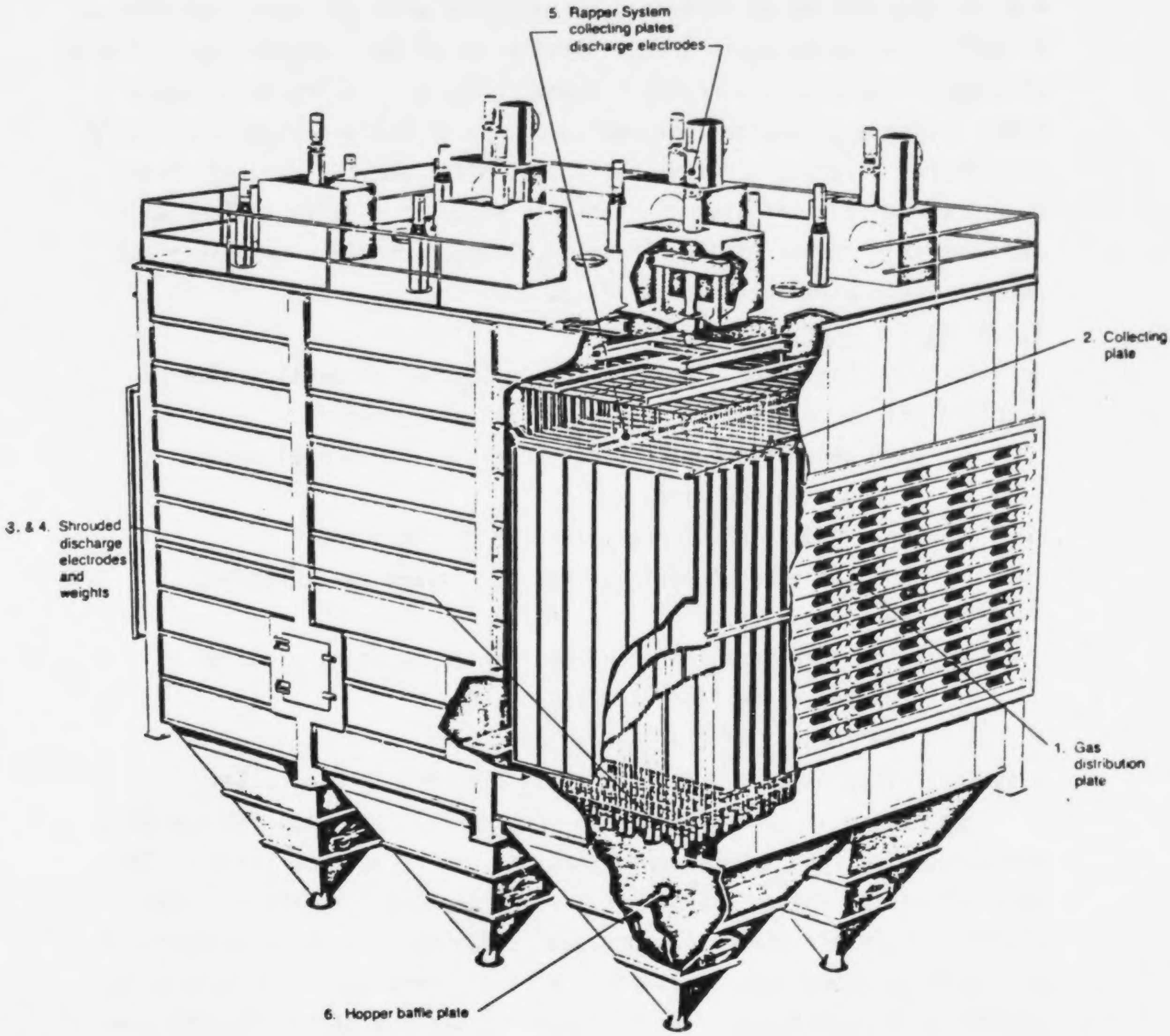
5. Rapper System
collecting plates
discharge electrodes
2. Collecting plate
3. & 4. Shrouded discharge electrodes and weights
1. Gas distribution plate
6. Hopper baffle plate

Figure 4-4. View of a typical electrostatic precipitator[6]

The suitability of particulate collection by electrostatic precipitation depends on the resistivity of the particles. Particulates with resistivities in the range of 5×10^3 to 2×10^{10} ohm-cm have been shown by experience to be the most suitable for electrostatic precipitation.[4] Particles with lower resistivities will give up their charge too easily and will be re-entrained in the gas stream. Particles with higher resistivities will coat the collecting plates and will be hard to dislodge. The coated plates will thus have diminished ability to attract charged particles.

4.1.3.2 Factors Affecting Performance. The key design variable for electrostatic precipitator design is the area of the collecting plate. The overall removal efficiency of the ESP can then be defined by the plate area, migration (or drift) velocity, and gas flow rate according to the Deutsch-Anderson equation:

$$n = 1 - e^{\frac{-WA}{Q}}$$

where n = removal efficiency

Q = gas flow rate

W = migration velocity

A = collecting plate area.

As indicated by this equation, ESP efficiency increases with increasing plate area relative to gas flow rate and with increasing migration velocity.

Another key design variable is proper determination of the rapping cycle. If the cycle is too short, material that collects on the collecting plates will not be thick enough to settle to the bottom of the precipitation chamber and will be re-entrained. This re-entrainment of collected particulates can be minimized by proper design of collecting electrodes and rappers, minimizing rapping, and rapping only a small section at a time. If the rapping cycle is too long, however, the material on the collecting plates will become too thick and collection efficiency will be reduced.

Other design parameters that affect ESP performance include plate spacing and type, plate height and length, applied voltage, corona strength, residence time, and transformer/rectifier configuration. ESP's typically have gas-phase pressure drops less than 1.3 cm (0.5 in.) of water.

Gas flow distribution also has a strong impact on ESP efficiency. Poor flow distribution results in variations in the extent of gas treatment. In addition, high velocities in the vicinity of hoppers and collecting electrodes can result in re-entrainment of collected dust. These effects of poor gas flow distribution cause a drop in ESP efficiency, often as much as 20 to 30 percent.[7] Gas flow distribution problems can be corrected by proper design, for example by adding straighteners, splitters, vanes, and diffusion plates to the duct work before the ESP. Scale models of the ESP and duct work are generally needed to study flow distribution problems and possible solutions.

4.1.4 Fabric Filtration[8,9]

4.1.4.1 Basic Description.[8] A fabric filter unit is illustrated in Figure 4-5. As the inlet gas passes through the fabric filters, dust particles in the inlet gas are retained on the fabric filters themselves by settling, impaction, interception, and diffusion. The bags are then cleaned in one of three ways. In shaker cleaning, the bags are oscillated by a small electric motor. The oscillation shakes most of the collected dust into a hopper. In reverse flow cleaning, backwash air is introduced to the bags to collapse them and fracture the dust cake. Both shaker cleaning and reverse flow cleaning require a sectionalized baghouse to permit cleaning of one section while other sections are functioning normally. The third cleaning method, reverse pulse cleaning, does not require sectionalizing. A short pulse of compressed air is introduced through venturis and directed from top to bottom of the bag. The primary pulse of air aspirates secondary air as it passes through the venturis. The resulting air mass expands the bag and fractures the cake. This method of cleaning can be effected simultaneously with the bag filter operation, avoiding the need for sectionalized baghouses.

4.1.4.2 Factors Affecting Performance. The most important parameters in baghouse design and performance are:

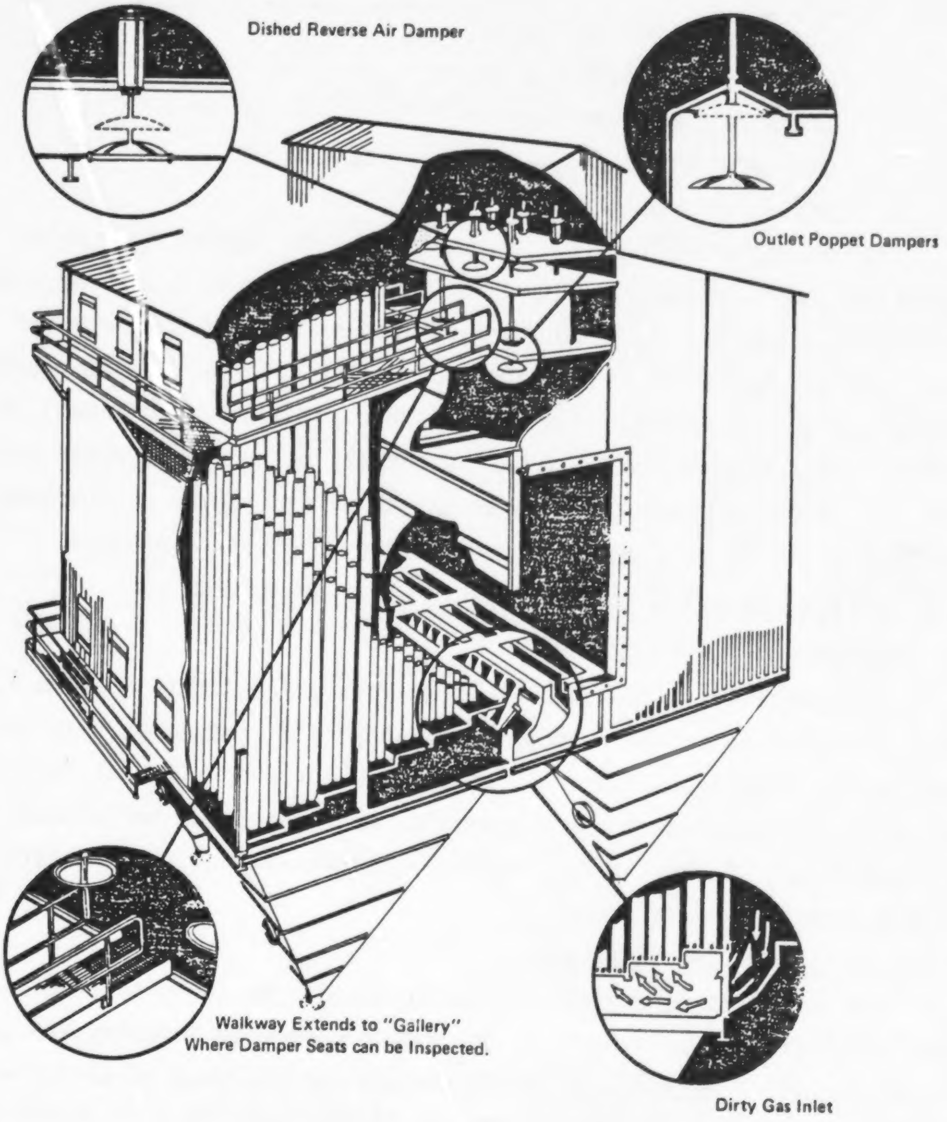
Dished Reverse Air Damper
Outlet Poppet Dampers
Walkway Extends to "Gallery" Where Damper Seats can be Inspected.
Dirty Gas Inlet

Figure 4-5. Example of a fabric filter.[9]

- filter medium,
- air to cloth ratio (superficial velocity),
- cleaning method and cycle,
- operational pressure drop,
- baghouse configuration,
- gas temperature and moisture content, and
- particulate properties.

The removal efficiency of fabric filters is reduced by poorly-maintained bags and caking. Worn and torn bags are evidenced by visible emissions; a regular inspection program can help to spot stress and wear. Caking can occur with hygroscopic materials when the temperature of the gas drops too low. Since caking can permanently ruin bags, a fabric filter by-pass or inlet gas heater may be needed to avoid caking when gas temperatures drop. Higher gas temperatures can be achieved by insulating bag filters and upstream ducting and control devices.

4.2 APPLICATION OF CONTROL TECHNIQUES TO FACILITIES IN THE SODIUM CARBONATE INDUSTRY

Applicability of the control techniques discussed in Section 4.1 to facilities in the sodium carbonate industry is discussed in this section. The control techniques currently being used for the different facilities are noted. Typical design and operating parameters and performance data are presented. Factors affecting the applicability of other control devices are also discussed.

4.2.1 Calciners and Bleachers

The only control devices currently being used to control emissions from calciners and bleachers in the sodium carbonate industry are cyclones in series with electrostatic precipitators and cyclones in series with venturi scrubbers. All but two of the fifteen calciners in use in monohydrate process plants are controlled by cyclones in series with electrostatic precipitators. The other two calciners are controlled by cyclones in series with venturi scrubbers. Bleachers are also most commonly controlled by cyclones in series with electrostatic precipitators.

Resistivity of calciner dust has been reported as 1 X 10^7 ohm-cm at 230°C (450°F).[10] This is within the range of resistivities that have been shown to be most suitable for electrostatic precipitation (as discussed in Section 4.1.3).

Other characteristics of sodium carbonate, such as its hygroscopic nature, lead to problems in ESP operation, but these can be overcome with proper design. Sodium carbonate dust is hygroscopic and sticky, and tends to cling to electrodes. It can also clog the openings of conventional pyramid dust hoppers, making dust removal difficult. When the dust is not removed, it can back up into the ESP and short out electrodes.[11,12] One vendor that has designed ESP's for sodium carbonate calciners recommends the use of a properly maintained drag bottom ESP rather than conventional pyramid hoppers for dust removal to minimize these dust removal problems.[11] The dust removal system in a drag bottom ESP consists of a square panel under the ESP, equipped with a drag conveyor to carry away the collected dust. The conveyor must be kept clear and moving to prevent dust from backing up into the electrodes. However, there are no narrow openings as in pyramid hoppers to become clogged. Problems can also result from moisture in the gas getting into the support insulation, where it forms a film which can cause cracks. A properly designed purge system can prevent such a film build up.[11]

ESP's are generally designed in sections, with separate electric fields controlled by separate transformer-rectifiers so that power input to one section is not limited by poor performance in another. ESP's on calciners and bleachers in sodium carbonate plants typically have three or four separate fields. There is also a trend to design the ESP to meet the guaranteed emission level with one section out of service.[11] Because of problems such as those noted above, it is not uncommon for ESP's in sodium carbonate plants to be operated with one section out of service. Design parameters and performance data supplied by industry for ESP's used to control emissions from calciners and bleachers in the sodium carbonate industry are presented in Table 4-1. Cyclones are used in front of the ESP's.

Venturi scrubbers currently used to control emissions from calciners achieve lower removal efficiencies than ESP's. Higher removal efficiencies could be achieved with higher scrubber pressure drops. Based on the removal efficiency achieved in EPA source tests of gas-fired calciners with a scrubber pressure drop of about 85 cm (33.5 in.) of

TABLE 4-1. DESIGN PARAMETERS AND PERFORMANCE DATA SUPPLIED BY INDUSTRY FOR ELECTROSTATIC PRECIPITATORS CONTROLLING EMISSIONS FROM CALCINERS AND BLEACHERS

Facility Type	ESP Vendor	No. of Stages	Ratio of Plate Area to Flow Rate		Design Efficiency	Migration Velocity[a]		Demonstrated Emission Level		Exit Particulate Concentration	
			$m^2/m^3/s$	$ft^2/1000$ acfm		m/s	ft/s	kg/Mg feed	lb/ton feed	g/dNm^3	gr/dscf
Gas-fired calciner #1	NA	NA[b]	NA	NA	NA	NA	NA	0.08	0.16	0.069	0.03
Gas-fired calciner #2	NA	NA	NA	NA	NA	NA	NA	0.13	0.25	0.13	0.056
Gas-fired calciner #3	NA	NA	NA	NA	NA	NA	NA	0.06	0.12	NA	NA
Gas-fired calciner #4	NA	NA	NA	NA	NA	NA	NA	0.07	0.14	0.046	0.02
Gas-fired calciner #5	NA	NA	NA	NA	NA	NA	NA	0.11	0.21	0.046	0.02
Gas-fired calciner #6	NA	3	50	255	99.55	0.11	0.35	0.065	0.13	0.11	0.048
Gas-fired calciner #7	NA	3	50	255	99.55	0.11	0.35	0.033	0.065	0.055	0.024
Gas-fired calciner #8	Research Cottrell	4	NA	NA	99.5	NA	NA	0.07	0.14	0.098	0.043
Gas-fired calciner #9	Research Cottrell	3	NA	NA	99.5	NA	NA	0.085	0.17	0.11	0.047
Gas-fired calciner #10	Research Cottrell	3	NA	NA	99.5	NA	NA	0.07	0.14	0.066	0.029
Gas-fired calciner #11	Research Cottrell	4	49	248	99.9	0.14	0.47	0.025	0.05	0.043	0.019
Coal-fired calciner #1[d]	Envirotech	4	67	338	98.89	0.068	0.22	0.032	0.062	0.015	0.0065
Coal-fired calciner #1[d]	Envirotech	4	65	329	99.89	0.11	0.35	0.031	0.062	0.019	0.0082
Coal-fired calciner #2[e]	Envirotech	4	63	319	98.89	0.072	0.24	0.014	0.028	0.0059	0.0026
Coal-fired calciner #2[e]	Envirotech	4	60	305	99.89	0.11	0.37	0.072	0.12	0.040	0.018
Gas-fired bleacher #1	Research Cottrell	3	35	180	99.81	0.18	0.58	NA	NA	0.096[c]	0.042[c]

[a] Calculated using the Deutsch-Anderson Equation

[b] NA=Not Available

[c] Design value

[d] These are different tests of the same calciner

[e] These are different tests of the same calciner

water, it appears that a pressure drop of about 154 cm (60 in.) of water may be required to achieve a removal efficiency comparable to that achieved in a four stage ESP.[13]

No fabric filters are used to control emissions from calciners or bleachers in sodium carbonate plants. The sticky, hygroscopic nature of sodium carbonate could lead to problems with bag blinding or caking, especially if the temperature is not maintained above the dew point. Baghouses are used to control emissions from other sources in sodium carbonate plants, such as conveyor transfer points, crushing, and product sizing. Some problems with bag blinding have been encountered.[14] Bag blinding may not be a problem with calciners and bleachers because these gas streams are at a high temperature, about 200-230°C (400-450°F) or about 160°C (290°F) above the dewpoint. Thus, with proper provisions for insulating the baghouse and for preventing sudden, uncontrolled shut-downs which would result in a rapid temperature drop in the baghouse, blinding may not be a serious problem.

4.2.3 Dryers and Predryers

Venturi scrubbers are the only control devices currently used to control emissions from rotary steam tube dryers in the sodium carbonate industry. Cyclones in series with venturi scrubbers are used to control emissions from fluid bed steam tube dryers and rotary steam heated predryers. Both venturi scrubbers and electrostatic precipitators have been used to control emissions from rotary gas-fired dryers.

The exhaust gas from both rotary and fluid bed steam tube dryers and predryers in the sodium carbonate industry is well suited to control by wet scrubbing. The sodium carbonate particles to be removed are quite soluble and hygroscopic. These characteristics enhance the removal of sodium carbonate particulates in wet scrubbers. However, when these characteristics are coupled with the high water content of the dryer exit gas, they can result in operating problems for ESP's or baghouses. The temperature of the exit gas from rotary steam tube dryers is about 88°C (190°F), or about 7 to 17°C (10 to 30°F) above the saturation temperature. Exit gas temperature from fluid bed dryers is about 130°C (250°F) or about 25-50°C (50-100°F) above saturation. Exit gas temperature from steam heated predryers is about 57°C (135°F) or about 13°C (25°F) above saturation. Thus, moisture in the exit gas could condense in an ESP or baghouse. Wet, sticky dust would then stick to the electrodes and hoppers of the ESP or blind and cake the bags in the baghouse.

ESP's have been used to control emissions from rotary gas-fired dryers, but the exit gas from these dryers is at a higher temperature and lower relative humidity than gas from steam tube dryers. Exit gas from a gas-fired dryer is about 150°C (300°F) with a moisture content of 20-25%, or about 90°C (160°F) above saturation temperature. As discussed in Chapter 3, gas-fired dryers are not expected to be used in future plants.

Design and operating parameters and performance data for scrubbers controlling particulate emissions from dryers and predryers in sodium carbonate plants are summarized in Table 4-2. As shown, scrubber pressure drops range from 33 cm (13 in.) water to 97 cm (38 in.) water. Higher scrubber pressure drops are required for fluid bed steam tube dryers and rotary gas-fired dryers than for rotary steam tube dryers to meet comparable emission levels. The higher pressure drops are required because uncontrolled emissions from fluid bed and gas-fired dryers are higher than those for rotary steam tube dryers. A cyclone is generally used before the scrubber for fluid bed and gas-fired dryers, so that the gas into the scrubber has a higher proportion of small particles than the gas from a rotary steam tube dryer.

4.3 DATA SUPPORTING PERFORMANCE

This section presents source test data demonstrating the level of emission control that has been achieved with the control techniques discussed in Section 4.2. Data obtained from EPA source tests are presented in Section 4.3.1. Industry data providing additional support to the performance level demonstrated in the EPA tests are presented in Section 4.3.2.

4.3.1 EPA Source Test Data

Source tests were conducted by EPA to demonstrate the performance of particulate control devices on facilities in sodium carbonate plants. Results of these tests are summarized below, and are presented in more detail in Appendix C.

TABLE 4-2. DESIGN AND OPERATING PARAMETERS AND PERFORMANCE DATA SUPPLIED BY INDUSTRY FOR SCRUBBERS USED TO CONTROL PARTICULATE EMISSIONS FROM DRYERS AND PREDRYERS

Facility Type	Scrubber Type	Vendor	Scrubber ΔP		L/G Ratio		Emission Rate		Exit Concentration	
			cmH_2O	in. H_2O	l/m^3	gal/1000 acf	kg/Mg Feed	lb/ton feed	g/dnm^3	gr/dscf
Rotary steam tube dryer #1	NA	NA	NA	NA	NA	NA	0.048	0.096	0.078	0.034
Rotary steam tube dryer #2	NA	NA	NA	NA	NA	NA	0.029	0.058	0.048	0.021
Rotary steam tube dryer #3	NA	NA	NA	NA	NA	NA	0.018	0.035	0.057	0.025
Rotary steam tube dryer #4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rotary steam tube dryer #5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rotary steam tube dryer #6	NA	NA	NA	NA	NA	NA	0.05	0.10	0.13	0.058
Rotary steam tube dryer #7	Venturi	Ducon	53[a]	21[a]	1.3[a]	10[a]	0.01	0.02	0.036	0.0157
Rotary steam tube dryer #8	Venturi	Ducon	53[a]	21[a]	1.3[a]	10[a]	NA	NA	NA	NA
Rotary steam tube dryer #9	Venturi	Ducon	53[a]	21[a]	1.3[a]	10[a]	NA	NA	NA	NA
Rotary steam tube dryer #10	Venturi	Ducon	53[a]	21[a]	1.3[a]	10[a]	0.0049	0.0098	0.027	0.0118
Rotary steam tube dryer #11	Venturi	Ducon	53[a]	21[a]	1.3[a]	10[a]	NA	NA	NA	NA
Gas-fired dryer #1	Venturi	Ducon	69	27.2	NA	NA	0.2	0.40	0.39	0.17
Fluid bed steam tube dryer #1	Venturi	FMC	97	38[b]	NA	NA	0.040	0.0795	0.048	0.021
Fluid bed steam tube dryer #2	Venturi	Ducon	66	26	NA	NA	0.081	0.161	0.064	0.028
Rotary steam tube dryer #12	Venturi	Ducon	48	19	NA	NA	0.0057	0.011	0.013	0.0058
Rotary steam tube dryer #13	Venturi	Ducon	48	19	NA	NA	0.010	0.021	0.027	0.012
Rotary steam heated predryer #1	Venturi-Rod	Riley	41	16[a]	1.5[a]	11[a]	NA	NA	0.074	0.0323[a]
Rotary steam tube dryer #14	Venturi	Polycon	33	13[a]	0.9[a]	7[a]	NA	NA	NA	NA

[a] design value

[b] pressure drop recorded during different source test

4.3.1.1 Cyclone/Electrostatic Precipitator on a Coal-fired Calciner.

Results of EPA source tests on a cyclone/electrostatic precipitator controlling emissions from a coal-fired calciner are presented in Table 4-3 and Figures 4-6 and 4-7. An average overall control efficiency of 99.96 percent was achieved for the cyclone/ESP combination, with resulting particulate emissions of 0.101 kg/Mg (0.202 lb/ton) dry feed. The average outlet particulate concentration was 0.0517 g/dry Nm^3 (0.0226 gr/dscf).[15] These emissions include emissions from the dissolver, which was vented to the calciner control device. The three test runs show a rather wide variation in emissions. However, since compliance is to be based on the average of three test runs, test data such as these would be acceptable to demonstrate compliance with the standard.

During the source tests, the calciner was operated at greater than 90 percent capacity. During tests 2 and 3 one section of the ESP was not in service. All sections were operating during the first test, but the first section was experiencing very low current and voltage.

4.3.1.2 Cyclone/Electrostatic Precipitator on a Gas-fired Bleacher

Results of EPA source tests on gas-fired bleachers controlled by cyclones and electrostatic precipitator are summarized in Table 4-4 and Figure 4-8. An average overall control efficiency of 99.99 percent was achieved for the cyclone/ESP combination, with resulting particulate emissions of 0.021 kg/Mg (0.041 lb/ton) dry feed. The average outlet particulate concentration was 0.0149 g/Nm^3 (dry) (0.0065 gr/dscf).[16]

The emission control scheme for the bleachers consisted of one ESP simultaneously treating emissions from three bleachers. Each bleacher was serviced by a separate cyclone. Only two of the three bleachers were operating during the tests. The two bleachers which were operational during testing were operated at greater than 65 percent but less than 90 percent of design capacity. However, calculations indicate that emissions at full capacity would average 0.026 kg/Mg (0.051 lb/ton) or less.[17]

The dry, standard gas flow rate to the emission control equipment on the bleacher was actually about 30 to 40 percent higher than the design gas flow rate. This was due to the admission of ambient air between the bleachers and the emission control equipment. (This ambient air was admitted for process

TABLE 4-3. CYCLONE/ELECTROSTATIC PRECIPITATOR PERFORMANCE DEMONSTRATED IN EPA TESTS OF A COAL-FIRED CALCINER[a]

Test Number	1	2	3	Average
Controlled Particulate Emission Rate				
kg/Mg dry feed	0.154	0.121	0.0284	0.101
lb/ton dry feed	0.307	0.241	0.0568	0.202
Controlled Particulate Concentration				
g/Nm^3 (dry)	0.0779	0.0615	0.0157	0.0517
gr/dscf	0.0340	0.0269	0.00684	0.0226
Overall Control Efficiency %	99.93	--[b]	99.99	99.96

[a] Reference 15

[b] Inlet particulate loading was not determined.

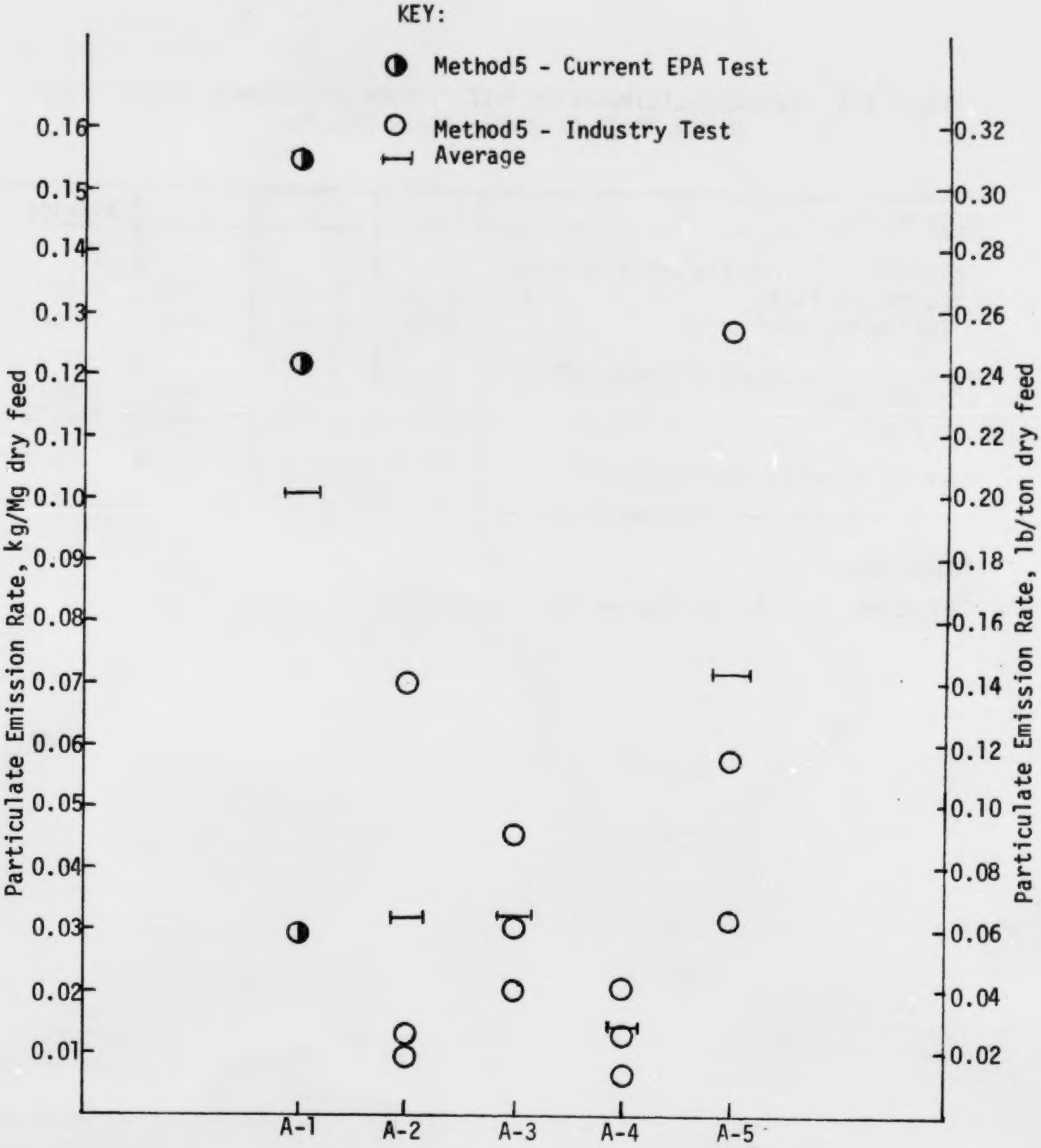

Figure 4-6. Controlled particulate emission rates from coal-fired calciners with cyclone/electrostatic precipitator.

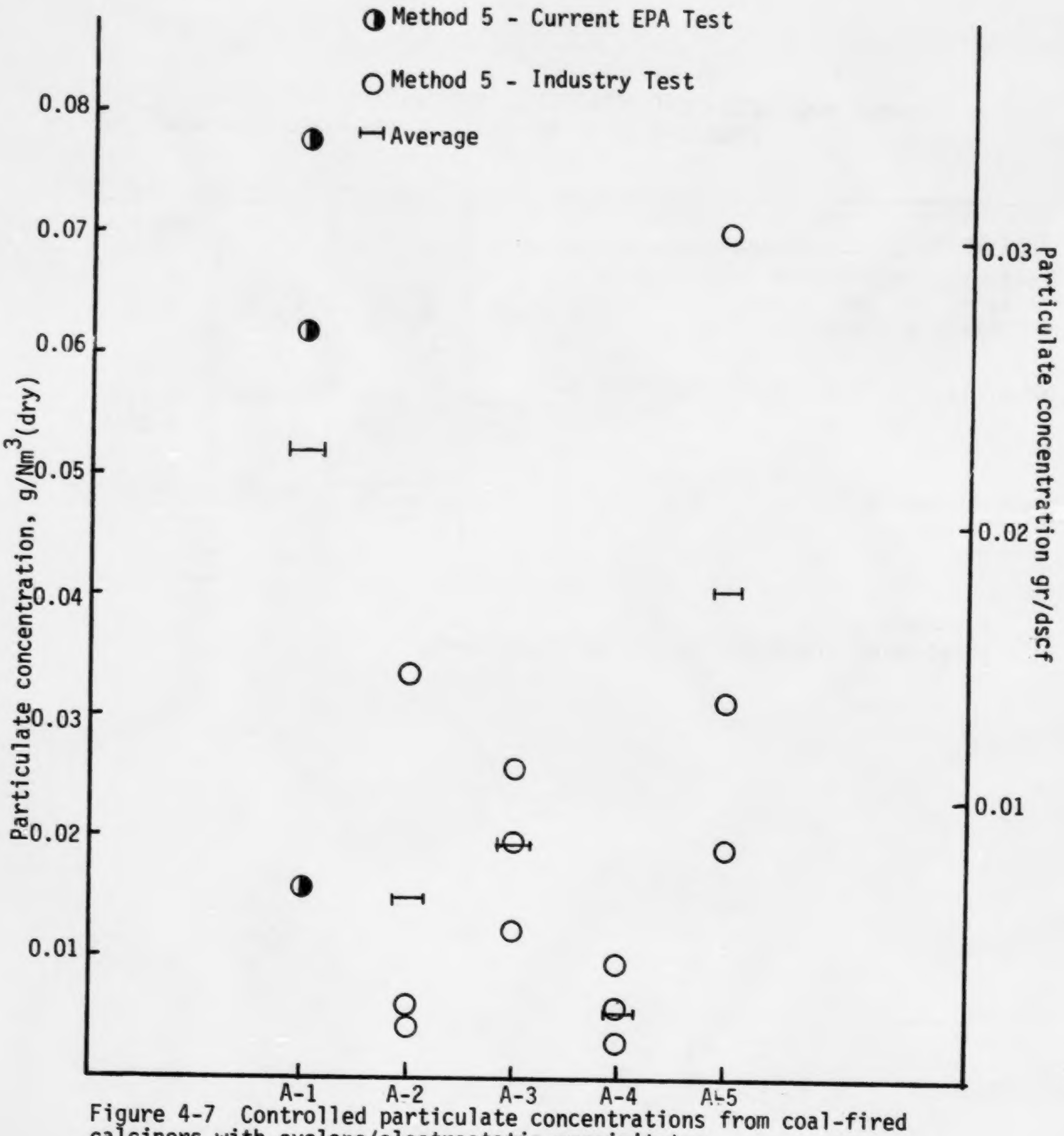

Figure 4-7 Controlled particulate concentrations from coal-fired calciners with cyclone/electrostatic precipitator

TABLE 4-4. CYCLONE/ELECTROSTATIC PRECIPITATOR PERFORMANCE DEMONSTRATED IN EPA TESTS OF GAS-FIRED BLEACHERS[a]

Test Number	1	2	3	Average
Controlled Particulate Emission Rate				
kg/Mg dry feed	0.031	0.019	0.012	0.021
lb/ton dry feed	0.061	0.038	0.024	0.041
Controlled Particulate Concentration				
g/Nm^3 (dry)	0.0234	0.0124	0.0089	0.0149
gr/dscf	0.0102	0.0054	0.0039	0.0065
Overall Control Efficiency %	b	99.99	99.99	99.99

a. Reference 16

b. Inlet particulate loading was not determined.

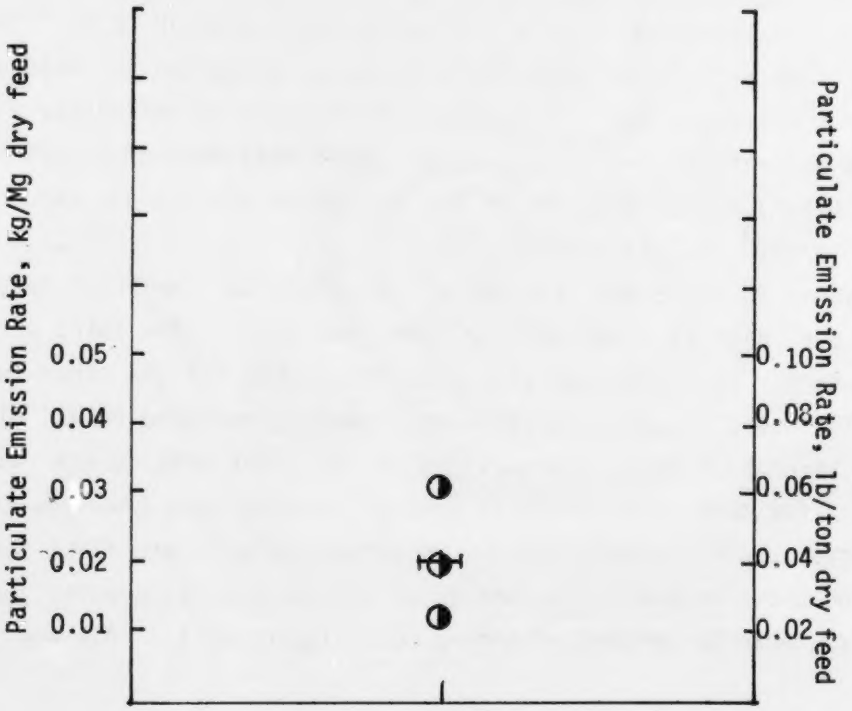

Figure 4-8 Controlled particulate emission rates from gas-fired bleachers with cyclone/electrostatic precipitator

control reasons.) The actual gas flow rate was about two to four percent less than the design rate.

4.3.1.3 Venturi Scrubber on a Rotary Steam Tube Dryer. Results of EPA source tests on a venturi scrubber controlling emissions from a rotary steam tube dryer are presented in Table 4-5 and in Figures 4-9 and 4-10. The average control efficiency was 99.88 percent, with resulting controlled emissions of 0.0356 kg/Mg (0.0711 lb/ton) dry product. The average outlet particulate concentration was 0.0867 g/dNm^3 (0.0379 gr/dscf).[15] During these tests, the dryer was operated at greater than 90 percent capacity.

4.3.1.4 Cyclone/Venturi Scrubber on a Fluid Bed Steam Tube Dryer. Results of EPA source tests on a cyclone/venturi scrubber controlling emissions from a fluid bed steam tube dryer are presented in Table 4-6 and Figures 4-9 and 4-10. The average overall control efficiency achieved was 99.92 percent, resulting in average outlet emissions of 0.0379 kg/Mg (0.0793 lb/ton) dry product and an average outlet particulate concentration of 0.0556 g/dNm^3 (0.0243 gr/dscf).[18]

As shown in Table 4-6, the outlet emissions for the first test are over twice as high as those for the other two tests. The inlet particulate rate for this test was also over twice that for the other two tests. The overall control efficiency, however, remained relatively constant throughout these fluctuations in the inlet particulate rate. The reason for this fluctuation is unknown, but may have been due to a higher dryer draft pressure that was observed early in the first test.

During these source tests, the dryer was operated at greater than 85 but less than 90 percent of normal operating capacity. Average

TABLE 4-5. VENTURI SCRUBBER PERFORMANCE DEMONSTRATED IN EPA TESTS OF A ROTARY STEAM TUBE DRYER[a]

Test Number	1	2	3	Average
Controlled Particulate Emission Rate				
kg/Mg dry product	0.0326	0.0480	0.0262	0.0356
lb/ton dry product	0.0651	0.0960	0.0523	0.0711
Controlled Particulate Concentration				
g/Nm^3 (dry)	0.0840	0.0973	0.0788	0.0867
gr/dscf	0.0367	0.0425	0.0344	0.0379
Overall Control Efficiency, %	99.87	99.86	99.90	99.88
Scrubber Pressure Drop[b]				
cm of water	62.2	63.2	64.8	63.4
in. of water	24.5	24.9	25.5	25.0

[a] Reference 15.

[b] Across throat.

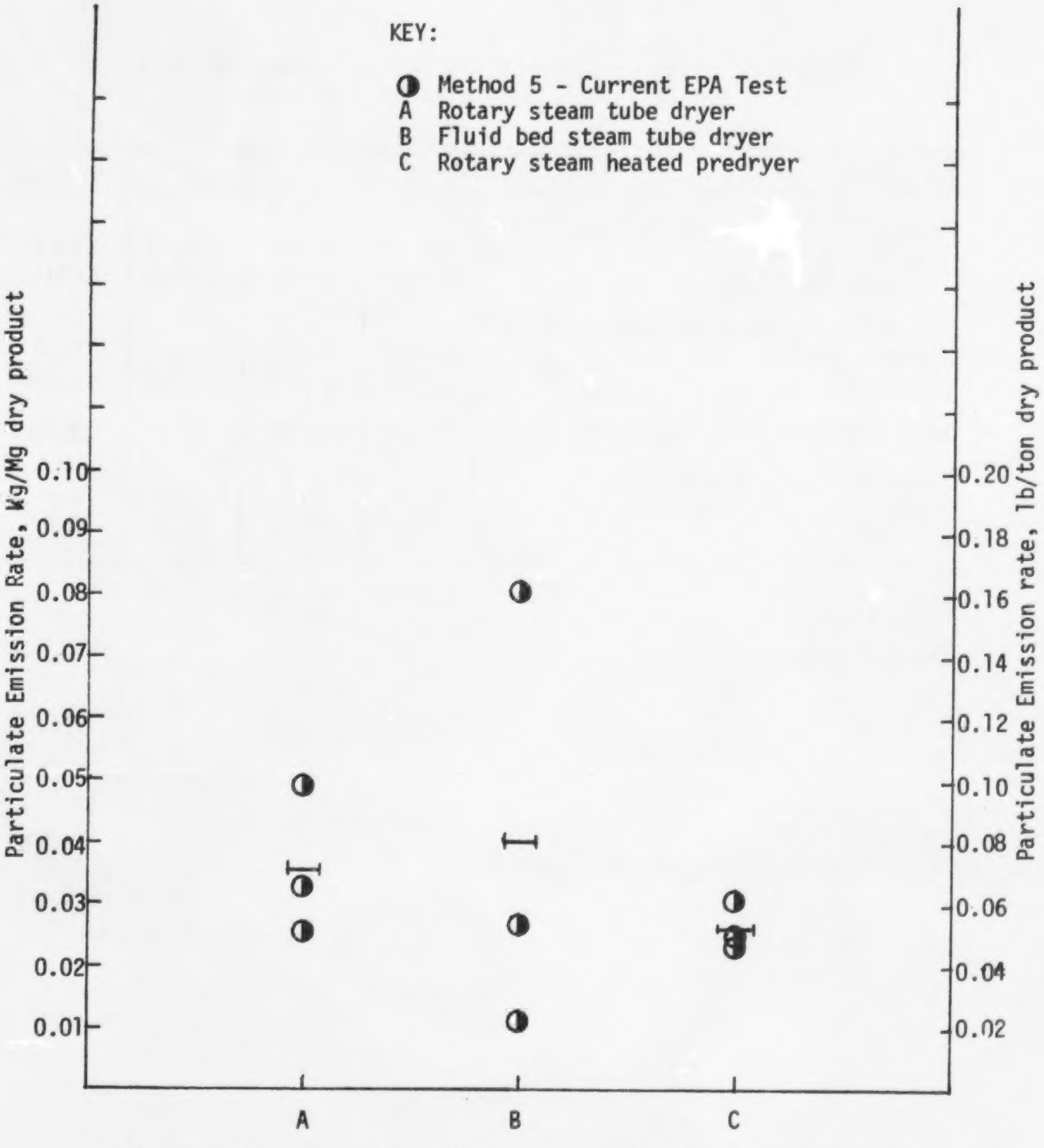

Figure 4-9. Controlled particulate emissions rates from rotary steam tube dryers, fluid bed steam tube dryers, and rotary steam heated predryers with venturi scrubbers.

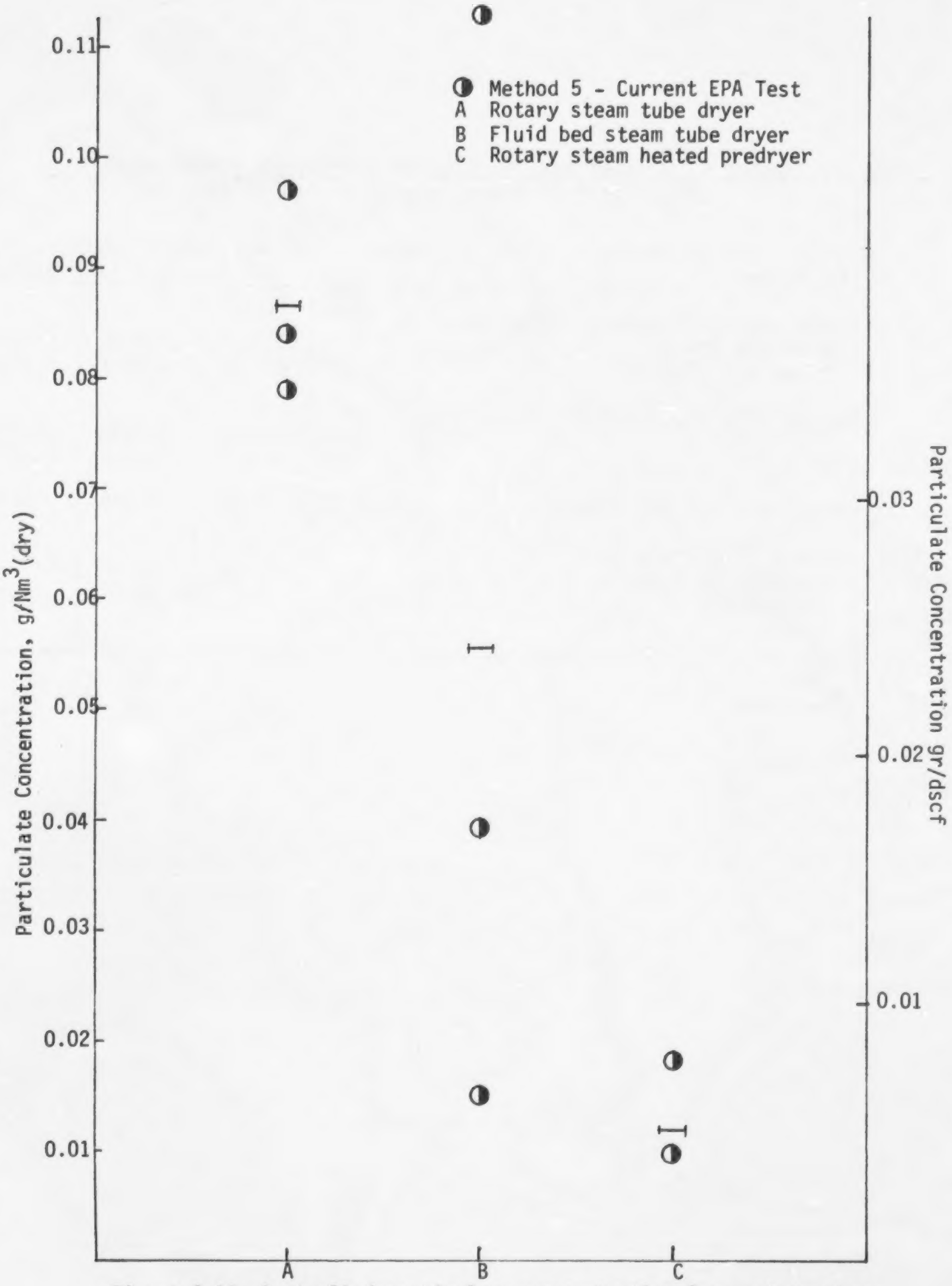

Figure 4-10 Controlled particulate concentration from rotary steam tube dryer, fluid bed steam tube dryer, and rotary steam heated predryers with venturi scrubbers.

TABLE 4.6. CYCLONE/VENTURI SCRUBBER PERFORMANCE DEMONSTRATED IN EPA TESTS OF A FLUID BED STEAM TUBE DRYER[a]

Test Number	1	2	3	Average
Controlled Particulate Emission Rate				
kg/Mg dry product	0.081	0.0271	0.0108	0.0397
lb/ton dry product	0.162	0.0542	0.0217	0.0793
Particulate Concentration				
g/Nm^3 (dry)	0.113	0.0390	0.0150	0.0556
gr/dscf	0.0494	0.0170	0.00655	0.0243
Overall Control Efficiency, %	99.88	99.91	99.96	99.92
Scrubber Pressure Drop				
cm water	98.6	95.8	93.5	96.0
inches water	38.8	37.7	36.8	37.8

[a] Reference 18

scrubber pressure drop during the tests was about 96 cm (38 inches) of water.

4.3.1.5 Cyclone/Venturi Scrubber on a Rotary Steam Heated Predryer. Results of EPA source tests on rotary steam heated predryers controlled by cyclones and a venturi scrubber are summarized in Table 4-7 and Figues 4-9 and 4-10. The average overall control efficiency was 98.3 percent with resulting controlled emissions of 0.026 kg/Mg (0.052 lb/ton) dry product. The average outlet particulate concentration was 0.0123 g/Nm^3(dry) (0.0054 gr/dscf).[16]

The emissions control system for the predryers consisted of a cyclone for each predryer, and one venturi rod scrubber for every two predryers. During the tests, the two predryers were operated at greater than 60 percent but less than 85 percent of their design capacity. However, calculations indicate that emissions at full capacity would average 0.04 kg/Mg (.08 lb/ton) or less.[17] The cyclone/venturi scrubber system was operated at a pressure drop of 46 cm (18") of water (about 43 cm (17") of water for the venturi alone). Some ambient air was admitted at the inlet to the venturi rod scrubber for process control reasons.

4.3.1.6 Cyclone/Venturi Scrubber on a Gas-fired Calciner. Results of EPA source tests on a cyclone/venturi scrubber controlling emissions from a gas-fired calciner are presented in Table 4-8. The emission reduction achieved is less than that achieved by a cyclone/ESP on a coal-fired calciner. At a pressure drop of 84.8 cm (33 in.) of H_2O the cyclone/ venturi scrubber control system achieved an emission rate of 0.182 kg/Mg versus a 0.101 kg/Mg emission rate achieved by the cyclone/ ESP system. In these tests, an average overall removal efficiency of 99.89 percent was achieved with an average scrubber pressure drop of 85 cm (33.4 in.) of water.

4.3.2 Industry Data Supporting Performance

Results of selected source tests conducted by the sodium carbonate

TABLE 4-7. CYCLONE/VENTURI SCURBBER PERFORMANCE DEMONSTRATED IN EPA TESTS OF ROTARY STEAM HEATED PREDRYERS

Test Number	1	2	3	Average
Controlled Particulate Emission Rate				
kg/Mg dry product	0.025	0.023	0.031	0.026
lb/ton dry product	0.049	0.046	0.061	0.052
Particulate Concentration				
g/Nm^3 (dry)	0.0094	0.0094	0.0181	0.0123
gr/dscf	0.0041	0.0041	0.0079	0.0054
Overall Control Efficiency, %	98.3	98.4	98.2	98.3
Cyclone Pressure Drop				
cm water	~2.0	~2.0	~2.0	~2.0
inches water	~0.80	~0.80	~0.80	~0.80
Venturi-Rod Scrubber Pressure Drop				
cm water	~43	~43	~43	~43
inches water	~17	~17	~17	~17

a Reference 16

TABLE 4.8. CYCLONE/VENTURI SCRUBBER PERFORMANCE DEMONSTRATED IN EPA TESTS OF A GAS-FIRED CALCINER[a]

Test Number	1	2	3	Average
Controlled Particulate Emission Rate				
kg/Mg Feed	0.149	0.216	0.182	0.182
lb/ton Feed	0.299	0.432	0.363	0.365
Controlled Particulate Concentration				
g/Nm^3 (dry)	0.214	0.279	0.268	0.254
gr/dscf	0.0935	0.122	0.117	0.111
Overall Control Efficiency, %	99.87	99.89	99.90	99.87
Scrubber Pressure Drop				
cm of water	85.6	85.1	83.8	84.8
in. of water	33.7	33.5	33.0	33.4

[a] Reference 17

industry are presented in this section. These tests were conducted to demonstrate compliance with state emission regulations. Few details were available on process operation or control equipment operating parameters during the tests. However, four tests conducted on coal-fired calciners using EPA Method 5 were judged by EPA's Emission Measurements Branch to be acceptable. Results of these tests are shown as points A-2 through A-5 on Figures 4-6 and 4-7 and are presented in Section 4.3.2.1.

4.3.2.1 Cyclone/Electrostatic Precipitator on a Coal-fired Calciner. Emission levels reported by industry for a cyclone/electrostatic precipitator controlling emissions from a coal-fired calciner are presented in Table 4-9. These reported emission levels are lower than those demonstrated in the EPA source tests (approximately 0.03 kg/Mg versus approximately 0.10 kg/Mg for the EPA tests). During tests I and II the calciners were operating at a capacity comparable to that during the EPA tests, and during tests III and IV they were operating at a lower capacity. During test I and III one field of the ESP was out of service. During test II all fields were in service, but the first two fields were operating with low currents. During test IV all fields were operating normally.

TABLE 4-9. EMISSION LEVELS REPORTED BY INDUSTRY FOR CYCLONE/ ELECTROSTATIC PRECIPITATORS ON COAL-FIRED CALCINERS[a]

Run Number	1	2	3	Average
I. Controlled Particulate Emission Rate				
kg/Mg Feed	0.0426	0.0200	0.0303	0.0310
lb/ton feed	0.0852	0.0400	0.0606	0.0619
Controlled Particulate Concentration				
g/Nm^3(dry)	0.0261	0.0117	0.0186	0.0188
gr/dscf	0.0114	0.00511	0.00812	0.00821
II. Controlled Particulate Emission Rate				
kg/Mg Feed	0.127	0.0575	0.0319	0.072
lb/ton Feed	0.253	0.115	0.0638	0.144
Controlled Particulate Concentration				
g/Nn^3(dry)	0.0705	0.0323	0.0181	0.0403
gr/dscf	0.0308	0.0141	0.00791	0.0176
III. Controlled Particulate Emission Rate				
kg/Mg feed	0.070	0.0134	0.0091	0.0308
lb/ton feed	0.140	0.0268	0.0182	0.0617
Controlled Particulate Concentration				
g/Nm^3 (dry)	0.0334	0.0069	0.0043	0.0149
gr/dscf	0.0146	0.0030	0.0019	0.0065
IV. Controlled Particulate Emission Rate				
kg/Mg feed	0.0134	0.0220	0.0061	0.0138
lb/ton feed	0.0268	0.0441	0.0123	0.0277
Controlled Particulate Concentration				
g/Nm^3 (dry)	0.0062	0.0092	0.0027	0.0059
gr/dscf	0.0027	0.0040	0.0012	0.0026

[a] Reference 19, 20. EPA Method 5 was used in all tests.

4.4 REFERENCES FOR CHAPTER 4

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5. MODIFICATION AND RECONSTRUCTION

Section 111 of the Clean Air Act, as amended in 1970, 1974, and 1977, requires the promulgation of standards of performance for new sources within a stationary source category which "...may contribute significantly to air pollution..." Affected facilities are those facilities for which applicable standards of performance have been promulgated and whose construction or modification began after proposal of the applicable standards.

When modified or reconstructed, "existing facilities" may become subject to standards of performance. As defined in 40 CFR 60.2, an "existing facility" is a facility for which a standard of performance has been promulgated and whose construction or modification began before proposal of that standard. On December 16, 1975, the Environmental Protection Agency promulgated amendments to the general provisions to clarify modification, and an added provision to define reconstruction. Section 5.1 summarizes those provisions of 40 CFR 60 defining the conditions under which existing facilities could become subject to standards of performance. Section 5.2 discusses the applicability of these provisions to facilities in sodium carbonate plants.

5.1 SUMMARY OF 40 CFR 60 PROVISIONS FOR MODIFICATIONS AND RECONSTRUCTIONS

5.1.1 Modification

Section 40 CFR 60.14 defines modification as follows:

> "Except as provided under paragraphs (d), (e) and (f) of this section, any physical or operational changes to an existing facility which result in an increase in emission rate to the atmosphere of any pollutant

> to which a standard applies shall be a modification. Upon modification, an existing facility shall become an affected facility for each pollutant to which a standard applies and for which there is an increase in the emission rate."

Paragraph (e) specifies certain physical or operational changes that are not considered as modifications irrespective of any changes in the emission rate. These changes include:

1) routine maintenance, repair, and replacement,
2) an increase in production rate accomplished without a capital expenditure (as defined in Section 60.2(bb)),
3) an increase in hours of operation,
4) use of alternate fuels or raw materials if the existing facility were designed to accommodate the alternate fuel or raw material prior to the standard (Conversion to coal required for energy considerations, as specified in Section 113(d) (5) of the amended Clean Air Act is also exempted.),
5) the addition or use of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or replaced by a system considered to be less efficient, and
6) relocation or change in ownership.

Paragraph (f) provides for superceding any conflicting provisions.

Paragraph (b) of CFR 60.14 clarifies what constitutes an increase in emissions and the methods for determining the increase. These methods include the use of emission factors, material balances, continuous monitoring systems, and manual emission tests. Paragraph (c) of CFR 60.14 affirms that the addition of an affected facility to a stationary source does not make any other facility within the source subject to standards of performance.

5.1.2 Reconstruction

Section 40 CFR 60.15 defines reconstruction as follows:

> "An existing facility, upon reconstruction, becomes an affected facility, irrespective of any change in emission rate. 'Reconstruction' means the replacement of components of an existing facility to such an extent that: (1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and (2) it is technologically and economically feasible to meet the applicable standards set forth in this part."

The purpose of this provision is to ensure that an existing facility is not perpetuated by replacing all but minor components such as support structures, frames, and housing rather than totally replacing the facility in order to avoid becoming subject to applicable standards of performance.

5.2 APPLICABILITY TO FACILITIES IN SODIUM CARBONATE PLANTS

According to the definitions presented in Section 5.1, very few modifications or reconstructions are likely to occur in the sodium carbonate industry.

Possible changes that could be termed modification would be the installation of larger fans on a dryer to allow an increase in production rate, or modifying the combustion chamber of a calciner to allow an increased fuel consumption rate and thus an increased production rate. Since increased particulate emissions would result from the increased production rate, these changes may be termed modifications. If these changes occur on a dryer or calciner controlled by a venturi scrubber, however, the scrubber pressure drop could be increased to provide additional particulate removal so that the controlled particulate emission rate would not increase. In this case, the change would not make the dryer or calciner subject to NSPS. However, comparable simple changes to improve the efficiency of an ESF would not be possible. These potential modifications are not expected to be common.

They would occur as part of an expansion by de-bottlenecking, when increased throughput would be possible in the remainder of the processing train so that modifying the calciner or dryer to allow increased throughput would increase the sodium carbonate production rate of the train.

Most other physical or operational changes that would occur to existing facilities in the sodium carbonate industry would not be defined as modifications or reconstructions. Physical changes that are likely to be made include relining of the calciner furnace, changes in the calciner combustion chamber, and replacement of portions of the drive mechanism of a calciner or dryer. These changes would be made as part of a routine repair and maintenance program and would not result in an increased emission rate. Thus, they would not be considered modifications. Moreover, since the cost of these changes would not exceed fifty percent of the capital cost of a new facility, these changes would not be considered reconstruction.

Other potential modifications include changes in fuels or raw materials. Use of fuel oil in a gas-fired calciner would not be a modification, since the existing gas-fired calciners are designed to burn both fuel oil and natural gas. Conversion of a gas- or oil-fired calciner to burn coal would potentially be a modification. However, because the calciner could process less ore when fired with coal than when fired with oil or gas, the actual mass rate of emissions from the calciner might not be increased in converting from gas to coal. In this case, the conversion to coal would not be a modification. If the mass emission rate is increased, improvements to the control device would be necessary to comply with state emission standards. The incremental cost to comply with NSPS for this modified case would be similar to the incremental cost for new facilities.

As noted in Chapter 3, there are a number of separate emission sources in sodium carbonate plants. Replacement or modification of one or more emission sources would not make the other sources in the processing train subject to NSPS.

6.0 MODEL PLANTS AND REGULATORY ALTERNATIVES

Model sodium carbonate plants and regulatory alternatives are defined in this chapter. These model plants and regulatory alternatives will be used in subsequent sections as the basis for analysis of the environmental and economic impacts associated with controlling particulate emissions from sodium carbonate facilities.

Process flow schemes, process parameters, and uncontrolled emission parameters for the model plants are described in Section 6.1. Regulatory alternatives are presented in Section 6.2.

6.1 MODEL PLANTS

The model sodium carbonate plants considered in this study are defined in Table 6-1. The rationale for defining the plants as combinations of separate trains is discussed in Section 6.1.1. Process configurations represented in the model plants are discussed in Section 6.1.2. Process and emission parameters for the model plants are presented in Section 6.1.3.

6.1.1 Rationale for Modular Approach

As discussed in Sections 3.1 and 8.1, sodium carbonate plants typically consist of combinations of separate trains. Major plant expansions involve the addition of new trains placed in parallel with existing trains. Thus, the model sodium carbonate plants considered in this study consist of essentially distinct trains, with a limited amount of shared equipment. The small plant consists of only one train and the medium size plant consists of two trains. The small plant case is representative of an expansion of an existing sodium carbonate plant. The medium size plant (2 trains) is representative of either a new plant or a larger expansion of an existing sodium carbonate plant.

TABLE 6-1. MODEL SODIUM CARBONATE PLANTS

Number	Plant size	Number of trains	Capacity, 10^6 Mg/yr (TPY)	Configuration	Process	Facilities in each train
1	Small	1	0.454 (0.5)	1	Monohydrate	Coal-fired calciner, rotary steam tube dryer
2	Medium	2	0.907 (1.0)	1	Monohydrate	Coal-fired calciner, rotary steam tube dryer
3	Small	1	0.454 (0.5)	2	Monohydrate	Coal-fired calciner, fluid bed steam tube dryer
4	Medium	2	0.907 (1.0)	2	Monohydrate	Coal-fired calciner, fluid bed steam tube dryer
5	Small	1	0.454 (0.5)	3	Direct carbonation	Rotary steam heated predryer, gas-fired bleacher, rotary steam tube dryer
6	Medium	2	0.907 (1.0)	3	Direct carbonation	Rotary steam heated predryer, gas-fired bleacher, rotary steam tube dryer

Each train has a capacity of 454,000 Mg/year (500,000 tons per year (TPY)). The newest sodium carbonate plant in operation using the monohydrate process and a monohydrate plant planned for construction both have two trains of this capacity. The production capacity of a train is limited by the size of equipment which can be shipped by rail. Coal-fired calciners for the monohydrate process and bleachers for the direct carbonation process for a train with capacities of 454,000 Mg/year approach this limiting size.

With the exception of two small direct carbonation plants built before 1970, all new natural process plants have had capacities of 454,000 Mg/yr or greater. As is noted in Section 8.1, most plant expansions have also been approximately this size or larger. The smaller expansions have been achieved by de-bottlenecking equipment in existing trains or by adding parts of a new train at different times. The new facilities added have generally had capacities corresponding to those in a 454,000 Mg/yr train. Thus, a 454,000 Mg/yr train was selected to represent expansions.

Sodium carbonate plants larger than 907,000 Mg/yr (one million TPY) are in operation, but (except for the 1.2 million Mg/yr direct carbonation plant) all capacity was not added at the same time. Therefore, no model plants were selected to represent a large sodium carbonate plant.

6.1.2 Process Configurations

Three different configurations are considered for the model plants. These configurations are shown in Figures 6-1 through 6-3. Configurations 1 and 2 use the monohydrate process, and configuration 3 uses the direct carbonation process.

These configurations have the following facilities, with individual train capacities as shown:

Configuration 1: (monohydrate)	1 rotary coal-fired calciner, 118 Mg/hr (130 TPH) 1 rotary steam tube dryer, 64 Mg/hr (70 TPH) dry product
Configuration 2: (monohydrate)	1 rotary coal-fired calciner, 118 Mg/hr (130 TPH) 1 fluid bed steam tube dryer, 64 Mg/hr (70 TPH) dry product

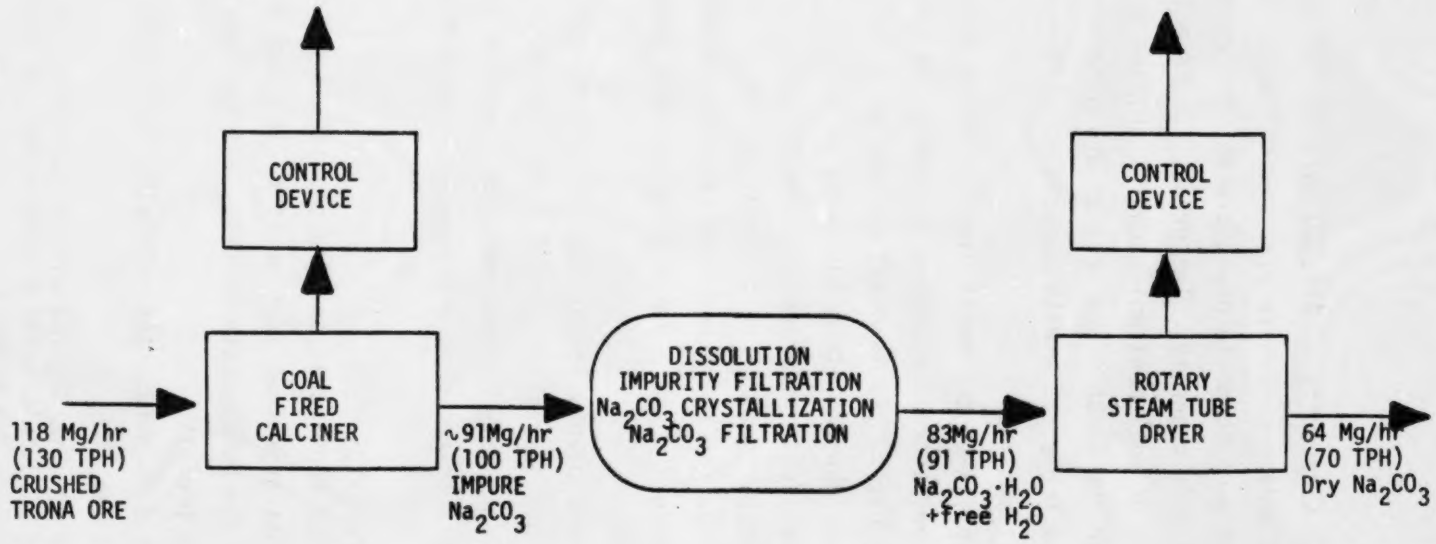

CONTROL DEVICE
CONTROL DEVICE
118 Mg/hr (130 TPH) CRUSHED TRONA ORE
COAL FIRED CALCINER
~91Mg/hr (100 TPH) IMPURE Na_2CO_3
DISSOLUTION
IMPURITY FILTRATION
Na_2CO_3 CRYSTALLIZATION
Na_2CO_3 FILTRATION
83Mg/hr (91 TPH) $Na_2CO_3 \cdot H_2O$ +free H_2O
ROTARY STEAM TUBE DRYER
64 Mg/hr (70 TPH) Dry Na_2CO_3

Figure 6-1. Model sodium carbonate plant - Configuration 1.
(monohydrate process)

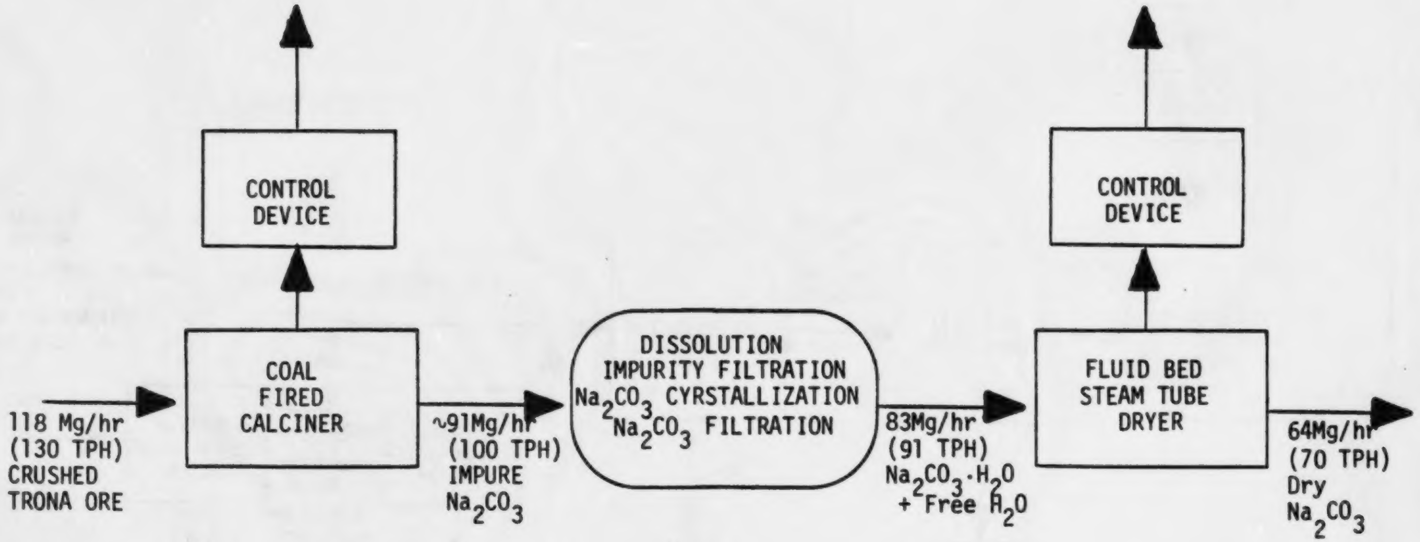

CONTROL DEVICE
CONTROL DEVICE
118 Mg/hr (130 TPH) CRUSHED TRONA ORE
COAL FIRED CALCINER
~91Mg/hr (100 TPH) IMPURE Na_2CO_3
DISSOLUTION
IMPURITY FILTRATION
Na_2CO_3 CYRSTALLIZATION
Na_2CO_3 FILTRATION
83Mg/hr (91 TPH) $Na_2CO_3 \cdot H_2O$ + Free H_2O
FLUID BED STEAM TUBE DRYER
64Mg/hr (70 TPH) Dry Na_2CO_3

Figure 6-2. Model sodium carbonate plant - Configuration 2.
(monohydrate process)

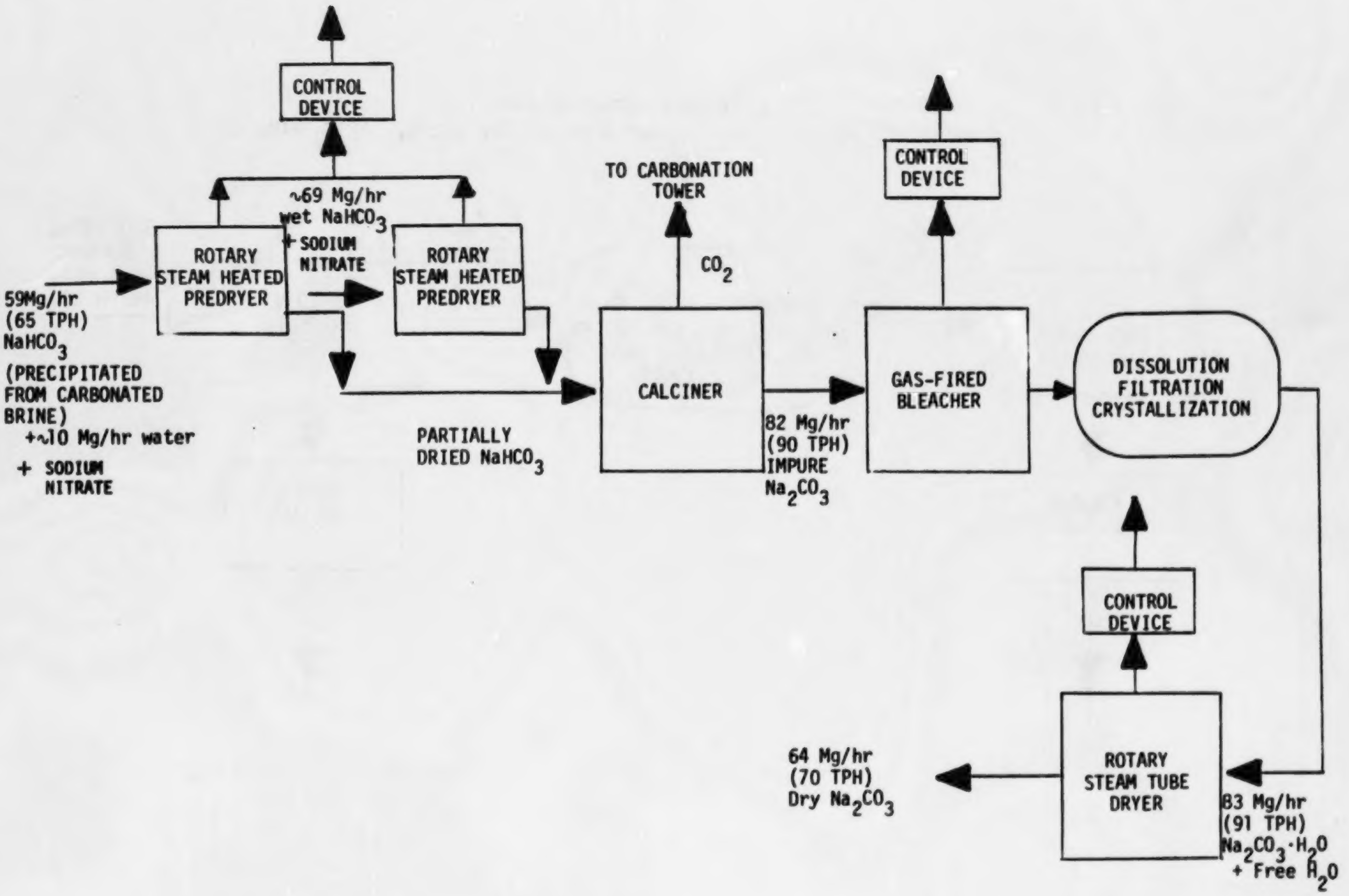

59Mg/hr
(65 TPH)
$NaHCO_3$
(PRECIPITATED
FROM CARBONATED
BRINE)
+~10 Mg/hr water
+ SODIUM
NITRATE
ROTARY
STEAM HEATED
PREDRYER
CONTROL
DEVICE
~69 Mg/hr
wet $NaHCO_3$
+ SODIUM
NITRATE
ROTARY
STEAM HEATED
PREDRYER
PARTIALLY
DRIED $NaHCO_3$
TO CARBONATION
TOWER
CO_2
CALCINER
82 Mg/hr
(90 TPH)
IMPURE
Na_2CO_3
CONTROL
DEVICE
GAS-FIRED
BLEACHER
DISSOLUTION
FILTRATION
CRYSTALLIZATION
CONTROL
DEVICE
ROTARY
STEAM TUBE
DRYER
83 Mg/hr
(91 TPH)
$Na_2CO_3 \cdot H_2O$
+ Free H_2O
64 Mg/hr
(70 TPH)
Dry Na_2CO_3

Figure 6-3. Model sodium carbonate plant - Configuration 3.
(direct carbonation process)

Configuration 3: 2 rotary steam heated predryers, 59 Mg/hr
(direct (65 TPH) each (dry feed)
carbonation) 1 rotary gas-fired bleacher, 82 Mg/hr (90 TPH)
1 rotary steam tube dryer, 64 Mg/hr (70 TPH)
dry product

Only the monohydrate and direct carbonation processes are represented in the model plants because all future plants are expected to use one of the processes. As discussed in Chapter 3, neither the sesquicarbonate process nor the Solvay process is expected to be used in future plants.

Although most of the calciners now used in sodium carbonate plants using the monohydrate process are fired with natural gas, only coal-fired calciners are represented in the model plants. Because of natural gas shortages and potential restrictions in natural gas use, new monohydrate process sodium carbonate plants are expected to use coal-fired calciners. The newest monohydrate plant in operation and a monohydrate plant planned for construction both use coal-fired calciners. Moreover, coal-fired calciners represent a more difficult case to control. Coal-fired calciners exhibit additional particulate loading due to fly ash in the coal and higher gas volumes due to higher excess air rates.

Both rotary and fluid bed steam tube dryers are represented in the model plants. Both dryer types are now in use in sodium carbonate plants and are expected to be the primary dryers used in future plants. The two dryer types have different gas flow rates and particulate loadings, and each has relative advantages in process operation which were detailed in Chapter 3. Natural gas-fired dryers are also currently in use in sodium carbonate plants, but their future use will be severely limited due to the unavailability and restricted use of natural gas. Thus, natural gas-fired dryers were excluded from the model plants.

6.1.3 Process and Emission Parameters

Raw material feed rates and compositions, product compositions, energy requirements and emission composition for each facility in the model sodium carbonate plants defined in Table 6-1 are presented in Table 6-2. Uncontrolled emission parameters for each facility in the model plants are presented in Table 6-3. These model plant parameters are

TABLE 6-2. PROCESS PARAMETERS FOR MODEL SODIUM CARBONATE PLANTS

Facility	Feed rate Mg/h (TPH)	Feed composition	Product	Fuel rate J/h (Btu/h)	Emission composition
Coal-fired calciner	118 (130)	~83% $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$ (sodium sesquicarbonate) ~15% insoluble impurities ~2% water	Impure Na_2CO_3	1.9×10^{11} - 2.0×10^{11} (1.8×10^{8} - 1.9×10^{8}) as coal	Particulates of impure Na_2CO_3 and clays. Fly ash, SO_2, organics
Rotary steam tube dryer	83 (91)	~90% $Na_2CO_3 \cdot H_2O$ (sodium carbonate monohydrate) ~10% free water	Na_2CO_3	~4.5×10^{10} (~4.3×10^{7}) as steam	Particulates of Na_2CO_3
Fluid bed steam tube dryer	83 (91)	~90% $Na_2CO_3 \cdot H_2O$ (sodium carbonate monohydrate) ~10% free water	Na_2CO_3	~5.1×10^{10} (~4.9×10^{7}) as steam	Particulates of Na_2CO_3
Steam heated predryer[a]	59 ea.[b] (65 ea.)	84-94% impure $NaHCO_3$ 6-16% water	85-95% impure $NaHCO_3$ 5-15% water	8.9×10^{9} - 3.4×10^{10} (8.5×10^{6} - 3.3×10^{7})	Particulates of impure $NaHCO_3$.
Gas-fired bleacher	82 (90)	Impure Na_2CO_3 Sodium nitrate (bleaching agent)	Bleached Na_2CO_3	3.3×10^{10} - 4.1×10^{10} (2.7×10^{7} - 3.6×10^{7}) as natural gas	Particulates of impure Na_2CO_3 and sodium nitrate

[a] There are two predryers per train.

[b] Dry basis.

TABLE 6-3. EMISSION PARAMETERS FOR UNCONTROLLED MODEL SODIUM CARBONATE PLANTS
(metric units)

Facility	Plant number[a]	Configuration	Particulate emission rate (kg/h)	Particulate concentration (g/dNm^3)[b]	Gas flow rate (actual) (m^3/min)	Gas flow rate (standard conditions) (Nm^3/min)[c]	Gas temperature (^oC)	Gas pressure (Pa)	Gas moisture content (percent)
Coal fired calciner	1(2)	1	23,000	119	8,700	4,010	230	8.06×10^4	20
Rotary steam tube dryer	1(2)	1	1,940	52	1,600	1,040	88	8.06×10^4	40
Coal fired calciner	3(4)	2	23,000	119	8,700	4,010	230	8.06×10^4	20
Fluid bed steam tube dryer	3(4)	2	4.54	59	3,120	1,840	120	8.06×10^4	30
Predryer[d]	5(6)	3	175	0.82	4,420	3,790	46	9.44×10^4	6
Bleacher	5(6)	3	2.57	70	1,170	668	204	9.44×10^4	8
Rotary steam tube dryer	5(6)	3	1,940	52	1,370	1,040	88	9.44×10^4	40

[a] Plant numbers in parentheses are for medium size plants. These plants have 2 trains, each of which has the emission sources and parameters presented. Thus, to give total emission rates and gas flow rates for the medium size plants, multiply the table values by 2.

[b] Standard conditions are 20^oC and 1.013×10^5 Pa.

[c] The reported value is actually a controlled flow rate. Information was not available to calculate an uncontrolled flow rate.

[d] The reported values are for both predryers in the train.

TABLE 6-3. EMISSION PARAMETERS FOR UNCONTROLLED MODEL SODIUM CARBONATE PLANTS
(English units)

Facility	Plant number[a]	Configuration	Particulate emission rate (lbs/hr)	Particulate concentration (gr/dscf)[b]	Gas flow rate (actual) (ft^3/min)	Gas flow rate (standard conditions) (scf/min)[b]	Gas temperature (°F)	Gas pressure (psia)	Gas moisture content (percent)
Coal fired calciner	1(2)	1	50,600	52	307,000	142,000	450	11.7	20
Rotary steam tube dryer	1(2)	1	4,280	23	56,600	36,600	190	11.7	40
Coal fired calciner	3(4)	2	50,600	52	307,000	142,000	450	11.7	20
Fluid bed steam tube dryer	3(4)	2	10,000	26	110,200	64,900	248	11.7	30
Predryer[d]	5(6)	3	385	0.36	156,000	134,000	115	13.7	6
Bleacher	5(6)	3	5,660	30	41,210	23,600	400	13.7	8
Rotary steam tube dryer	5(6)	3	4,280	23	48,300	36,600	190	13.7	40

[a] Plant numbers in parentheses are for medium size plants. These plants have 2 trains, each of which has the emission sources and parameters presented. Thus, to give total emission rates and gas flow rates for the medium size plants, multiply the table values by 2.

[b] Standard conditions are 68°F and 14.7 psia.

[c] The reported value is actually a controlled flow rate. Information was not available to calculate an uncontrolled flow rate.

[d] The reported values are for both predryers in the train.

based upon the data presented in Chapter 3 and Appendix C, scaled to the appropriate size.

Each facility in the model sodium carbonate plants is operated approximately 7,446 hours per year (operating factor of 85%) and is generally operated at or near full capacity. Each train requires a land area of about 971,000 m^2 (240 acres).

6.2 REGULATORY ALTERNATIVES

6.2.1 Approach

Regulatory alternatives considered for application to the model sodium carbonate plants are summarized in Table 6-4. For each facility, two basic options were considered:

- controlling emissions to the baseline level, which would be required under existing state regulations, and
- controlling emissions to a more stringent level based on the best level of emission reduction demonstrated in the sodium carbonate industry.

These two options for each facility were combined into two regulatory alternatives for each model sodium carbonate plant:

- Alternative 1 - baseline control for all facilities
- Alternative 2 - more stringent control for all facilities.

Other possible alternatives would be controlling some facilities to the more stringent level and others to the baseline level. These alternatives were not considered.

Another possible alternative would be a combined standard for all the facilities in a plant. This alternative was not investigated because it would create enforcement problems in the case of plant modifications or expansions involving only some of the facilities.

For all facilities, particulate control equipment would be required to meet the baseline level. The more stringent control levels would be met by applying a more efficient control device, such as a higher pressure drop scrubber or an ESP with greater plate area.

6.2.2 Control Systems

As discussed in Chapter 4, several different emission control systems can be used to control emissions from each facility to meet the regulatory alternatives presented in Section 6.2.1. The control systems selected for analysis of environmental and economic impacts are discussed in this section. For most facilities, the control systems used for high efficiency applications could be the same type as those used to meet the baseline level, but designed and operated for a higher control efficiency.

6.2.2.1 Calciners. Cyclones followed in series by electrostatic precipitators are the most common and most efficient control devices currently used for controlling particulate emissions from calciners in sodium carbonate plants. This technique can be used to meet either the baseline level or a more stringent level corresponding to the other regulatory options. An ESP used to meet the more stringent emission level would have a larger plate area than an ESP used to meet the baseline level.

6.2.2.2 Dryers and Predryers. Venturi scrubbers are the only control devices currently used to control emissions from steam tube dryers and steam heated predryers in the sodium carbonate industry. Cyclones are used before the scrubbers for fluid bed steam tube dryers and steam heated predryers, but are not used with rotary steam tube dryers. A venturi scrubber or cyclone/venturi scrubber could be used to meet the baseline emission level or a more stringent emission level. The scrubber would be operated at a higher pressure drop to meet the more stringent emission level.

6.2.2.3 Bleacher. As with calciners, cyclones followed in series by electrostatic precipitators are most commonly used for control of emissions from bleachers. This cyclone/ESP combination could be used to meet the baseline emission level or a more stringent emission level. A larger plate area would be required for the ESP to meet a more stringent emission level.

TABLE 6-4. REGULATORY ALTERNATIVES FOR MODEL SODIUM CARBONATE PLANTS

Number	Configuration	Plant size[a]	Alternative	Calciner[b]	Dryer	Predryer	Bleacher
1a	1	small	1	baseline	baseline		
1b	1	small	2	high eff. ESP	high eff. VS		
2a	1	med.	1	baseline	baseline		
2b	1	med.	2	high eff. ESP	high eff. VS		
3a	2	small	1	baseline	baseline		
3b	2	small	2	high eff. ESP	high eff. VS		
4a	2	med.	1	baseline	baseline		
4b	2	med.	2	high eff. ESP	high eff. VS		
5a	3	small	1		baseline	baseline	baseline
5b	3	small	2		high eff. VS	high eff. VS	high eff. ESP
6a	3	med.	1		baseline	baseline	baseline
6b	3	med.	2		high eff. VS	high eff. VS	high eff. ESP

[a] Small plant has one train; medium plant has two trains.

[b] ESP = electrostatic precipitator

VS = venturi scrubber

7. ENVIRONMENTAL IMPACTS

This chapter discusses the environmental impacts associated with the promulgation of New Source Performance Standards (NSPS) for particulate emissions from emission sources in the sodium carbonate industry. The emission sources to be considered are calciners, dryers, predryers, and bleachers. The air quality, water pollution, solid waste, and energy impacts associated with the application of the alternative regulatory options are identified and discussed in Sections 7.1 to 7.4 respectively. Additional impacts and commitment of natural resources are evaluated in Sections 7.5 and 7.6 respectively. These impacts on the environment are also projected over a five year period after proposal of the NSPS to determine the long range national impact. All impacts are based on the model plant parameters presented in Chapter 6.

7.1 AIR POLLUTION IMPACT

7.1.1 Characteristics of Emissions from Affected Facilities

The largest emission source in the sodium carbonate industry is the coal fired calciner. Emissions consist of particulates, combustion gases (SO_2, NO_x), and organics (due to oil shale in trona ore). The particulates, consisting mainly of Na_2CO_3, clays, and fly ash, are emitted in much greater quantities than any other pollutant. The other emission sources emit primarily Na_2CO_3 particulates.

7.1.2 Summary of Regluatory Alternatives

As discussed in Chapter 6, two regulatory alternatives were considered for the emission sources: a baseline regulatory option, and a second more stringent control option for all emission sources.

The baseline emissions of particulates are as follows:

- calciner - 0.08 to 0.15 kg/Mg feed
- dryer - 0.074 to 0.25 kg/Mg product (monohydrate); 0.08 kg/Mg (direct carbonation)
- predryer - 0.14 kg/Mg feed
- bleacher - 0.060 kg/Mg feed.

These baseline emission levels represent the exepcted controlled emission levels prevailing in the absence of federally promulgated New Source Performance Standards. The rationale for selection of these baseline levels is presented in Section 3.3.

The expected ambient air quality impacts of the proposed alternatives are compared in Section 7.1.3. Annual emissions under each regulatory option, projected on a five year basis, will be discussed in Section 7.1.4.

7.1.3 Primary Air Quality Impacts

A dispersion analysis was performed on each alternative to determine the impacts of emissions from the model sodium carbonate plants on ambient air quality. This was done using the model plants described in Chapter 6. The higher value for baseline emissions (based on the process weight regulation) was used in the dispersion analysis.

7.1.3.1 Emission Source Characteristics. Stack parameters for each facility for the different control alternatives are presented in Table 7-1. These parameters are based on information from source tests, trip reports, and emission inventories.[1,2,3,4,5]

The stack configurations of each of the plants are shown in Figure 7-1. For each plant the process train was aligned with the prevailing wind direction to yield maximum ambient concentration.

TABLE 7-1. STACK PARAMETERS FOR MODEL SODIUM CARBONATE PLANTS (metric units)

Emission source	Case[a] number	Type of control	Particulate emission rate (kg/hr)	concentration $(g/dNm^3)^c$	Gas flow rate (actual) (m^3/min)	Gas flow rate (standard) $(Nm^3/min)^c$	Gas temperature (°C)	Gas pressure (Pa)	Gas H_2O content (vol.%)	Stack height (m)	Stack diameter (m)	Gas velocity (m/sec)
Coal-fired calciner	1a(2a)	c/ESP	17.3	0.090	8690	4090	232	8.06×10^4	20	40	2.44	31.1
Rotary steam tube dryer	1a(2a)	VS	15.9	0.43	1550	1050	71	8.06×10^4	41	34	1.37	17.4
Coal-fired calciner	1b(2b)	c/ESP	11.8	0.061	8690	4020	232	8.06×10^4	20	40	2.44	31.1
Rotary steam tube dryer	1b(2b)	VS	2.54	0.068	1550	1050	71	8.06×10^4	41	34	1.37	17.4
Coal-fired calciner	3a(4a)	c/ESP	17.3	0.090	8690	4020	232	8.06×10^4	20	40	2.44	31.1
Fluid bed steam tube dryer	3a(4a)	c/VS	15.9	0.21	2790	1900	66	8.06×10^4	32	34	1.83	17.7
Coal-fired calciner	3b(4b)	c/ESP	11.8	0.061	8690	4020	232	8.06×10^4	20	40	2.44	31.1
Fluid bed steam tube dryer	3b(4b)	c/VS	2.54	0.033	2790	1900	66	8.06×10^4	32	34	1.83	17.7

TABLE 7-1 (continued). STACK PARAMETERS FOR MODEL SODIUM CARBONATE PLANTS (metric units)

Emission source	Case [a] number	Type of control	Particulate emission rate (kg/hr)	Particulate concentration (g/dNm^3/)[c]	Gas flow rate (actual) (m^3/min)	Gas flow rate (standard) (Nm^3/min)	Gas temperature (^oC)	Gas pressure (Pa)	Gas H_2O content (vol.%)	Stack height (m)	Stack diameter (m)	Gas velocity (m/sec)
Rotary steam tube predryer[d]	5a(6a)	VS	16.5	0.078	4530	3910	43	9.44×10^4	9	34	2.44	16.2
Gas-fired bleacher	5a(6a)[e]	c/ESP	4.90	0.13	1170	668	204	9.44×10^4	8	34	1.22	16.7
Rotary steam tube dryer	5a(6a)	VS	5.08	0.14	1330	1040	74	9.44×10^4	40	34	1.37	15.0
Rotary steam tube predryer[d]	5b(6b)	VS	4.72	0.023	4530	3910	43	9.44×10^4	9	34	2.44	16.2
Gas-fired bleacher	5b(6b)	c/ESP	1.63	0.044	1170	668	204	9.44×10^4	8	34	1.22	16.7
Rotary steam tube dryer	5b(6b)	VS	2.54	0.068	1330	1040	74	9.44×10^4	40	34	1.37	15.0

[a] Configurations for each case are shown in Figure 7-1. Case numbers in parentheses are for the medium size plants. These plants have 2 trains, each of which has the emission sources and parameters presented. Thus, to give total emission rates and gas flow rates for the medium size plants, multiply the table values by 2.

[b] c = cyclone
VS = venturi scrubber
ESP = electrostatic precipitator

[c] Standard conditions are 20^{o}C (68^{o}F) and 1.013×10^5 Pa (1 atm.).

[d] The reported values are for both predryers in the train.

TABLE 7-1. STACK PARAMETERS FOR MODEL SODIUM CARBONATE PLANTS
(English units)

Emission source	Case[a] number	Type of Control	Particulate emission rate (lb/hr)	Particulate concentration (gr/dscf)[c]	Gas flow rate (actual) (ft^3/min)	Gas flow rate (standard) (ft^3/min)[c]	Gas temperature (^oF)	Gas pressure (psia)	Gas H_2O content (vol.%)	Stack height (ft)	Stack diameter (ft)	Gas velocity (ft/sec)
Coal-fired calciner	1a(2a)	c/ESP	38.2	0.039	307,000	142,000	450	11.7	20	130	8.0	102
Rotary steam tube dryer	1a(2a)	VS	35.0	0.19	54,600	37,000	160	11.7	41	110	4.5	57.2
Coal-fired calciner	1b(2b)	c/ESP	26.0	0.027	307,000	142,000	450	11.7	20	130	8.0	102
Rotary steam tube dryer	1b(2b)	VS	5.6	0.030	54,600	37,000	160	11.7	41	110	4.5	57.2
Coal-fired calciner	3a(4a)	c/ESP	38.2	0.039	307,000	142,000	450	11.7	20	130	8.0	102
Fluid bed steam tube dryer	3a(4a)	c/VS	35.0	0.090	98,400	67,200	150	11.7	32	110	6.0	58.0
Coal-fired calciner	3b(4b)	c/ESP	26.0	0.027	307,000	142,000	450	11.7	20	130	8.0	102
Fluid bed steam tube dryer	3b(4b)	c/VS	5.6	0.014	98,400	67,200	150	11.7	32	110	6.0	58.0
Rotary steam tube predryer[d]	5a(6a)	VS	36.3	0.034	160,000	130,000	110	13.7	9	110	8.0	53.1
Gas-fired bleacher	5a(6a)[e]	c/ESP	10.8	0.058	41,210	23,600	400	13.7	8	110	4.0	54.7

TABLE 7-1 (continued). STACK PARAMETERS FOR MODEL SODIM CARBONATE PLANTS
(English units)

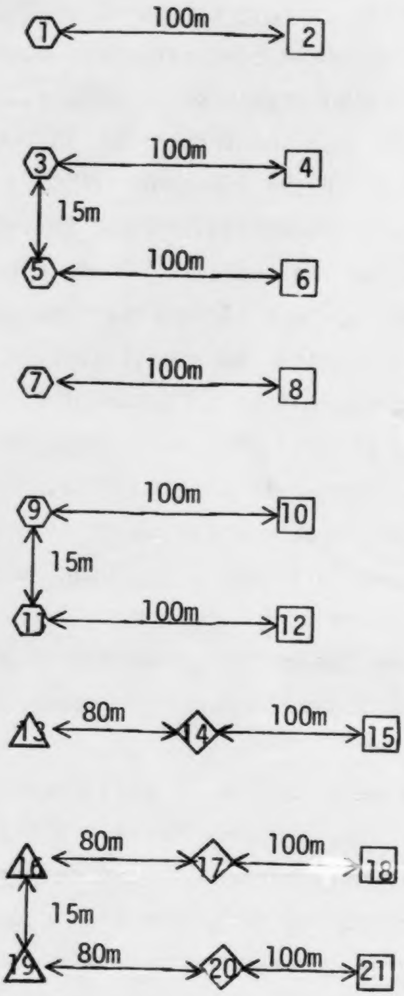
Emission source	Case[a] number	Type of control	Particulate emission rate (lb/hr)	Particulate concentration (gr/dscf)[c]	Gas flow rate (actual) (ft^3/min)	Gas flow rate (standard)[c] (ft^3/min)	Gas temperature (°F)	Gas pressure (psia)	Gas H_2O content (vol.%)	Stack height (ft)	Stack diameter (ft)	Gas velocity (ft/sec)
Rotary steam tube dryer	5a(6a)	VS	11.2	0.060	46,900	36,900	166	13.7	40	110	4.5	49.1
Rotary steam tube predryer[d]	5b(6b)	VS	10.4	0.010	160,000	138,000	110	13.7	9	110	8.0	53.1
Gas-fired bleacher	5b(6b)	c/ESP	3.6	0.019	41,210	23,600	400	13.7	8	110	4.0	54.7
Rotary steam tube dryer	5b(6b)	VS	5.6	0.030	46,900	36,900	166	13.7	40	110	4.5	49.1

[a] Configurations for each case are shown in Figure 7-1. Case numbers in parentheses are for the medium size plants. These plants have two trains, each of which has the emission sources and parameters presented. Thus, to give total emission rates and gas flow rates for the medium size plants, multiply the table values by 2.

[b] c = cyclone
VS = venturi scrubber
ESP = electrostatic precipitator

[c] Standard conditions are 20°C (68°F) and 1.013×10^5 Pa (1 atm.).

[d] The reported values are for both predryers in the train.

Model Plant	Stack Configuration[1]	Production Rate
Plant 1: (cases 1a,1b) Monohydrate process		454,000 Mg per year
Plant 2: (cases 2a,2b) Monohydrate process		907,000 Mg per year
Plant 3: (cases 3a,3b) Monohydrate process		454,000 Mg per year
Plant 4: (cases 4a,4b) Monohydrate process		907,000 Mg per year
Plant 5: (cases 5a,5b) Direct carbonation process		454,000 Mg per year
Plant 6: (cases 6a,6b) Direct carbonation process		907,000 Mg per year

1
100m
2
3
100m
4
15m
5
100m
6
7
100m
8
9
100m
10
15m
11
100m
12
13
80m
14
100m
15
16
80m
17
100m
18
15m
19
80m
20
100m
21

Figure 7-1. Stack configurations for model sodium carbonate plants.

KEY

[1]coal fired calciner	⬡
dryer	□
predryer	△
bleacher	◇

7.1.3.2 Meteorological Data and Model Assumptions. The dispersion analysis was performed to determine the maximum 24 hour and annual average ambient air concentrations of particulates and the distance from the stack at which these concentrations occur. Concentrations were also predicted at downwind distances of 100, 1,000, and 10,000 meters.

The analysis used the Industrial Source Complex (ISC) Model. The short term version of the ISC model (ISCST) was used to calculate the hourly particulate concentrations due to each source individually and to the combinations of the sources. These concentrations were averaged each day to obtain the maximum 24 hour average concentrations, and over the entire year to determine the annual average. The ISC model has been shown to be accurate within a factor of 2.

Monohydrate plants (Case 1-4) would most likely be built in a location similar to Sweetwater County, Wyoming. The available meteorological data which are most representative of this area are Rock Springs, Wyoming (surface data) and Salt Lake City, Utah (upper air data). Direct carbonation plants (Case 5, 6) would most likely be located near Trona, California, where the most representative available meteorological data are that for Las Vegas, Nevada. Meteorological data from 1964 were used in all cases.

All plants were assumed to be located in rural areas with relatively flat terrain. Thus, the only terrain effects included in the analysis were those inherently present in the meteorological data.

All meteorological data were examined for invalid wind data on days when 24 hour maximum concentrations were calculated. A total of 396 receptors were arranged around each plant, in radials separated by 10 degrees, to determine the maximum concentrations and their locations. Receptors were placed at 100, 225, 360, 500, 750, 1,000, 1,250, 1,500, 2,000, 5,000, and 10,000 meters to ensure the proper calculation of the maximum concentration.

7.1.3.3 Results and Discussions. Tables 7-2 and 7-3 summarize the results of the dispersion modeling analysis. All of the calculated ambient concentrations (even for baseline control levels) are well below the

National Ambient Air Quality Standards (primary standards: annual geometric mean = 75 ug/m^3. 24 hour concentration = 260 ug/m^3; secondary standards: annual geometric mean = 60 ug/m^3, 24 hour concentration = 150 ug/m^3). The values presented represent concentrations in a pristine atmosphere, and any background concentrations present at the plant sites should be added to the calculated concentrations.

A comparison of the percent reduction in ambient conentrations caused by switching from Alternative 1 to Alternative 2 is presented in Table 7-4.

As indicated in Table 7-2, the greatest contributor to the ambient concentration for the monohydrate plants in the Alternative 1 and 2 cases is the dryer exhaust. Compared to the calciner stack concentrations, the dryer emissions are small. However, due to the lower exit temperatures and high moisture content of the scrubber exhaust, the dryer stack plume has a low buoyancy. As a result, the maximum ambient concentrations due to dryer emissions are higher than those due to calciner emissions. The maximum concentration due to dryer emissions occurs at a point closer to the stack than the maximum concentration due to calciner emissions. For the direct carbonation plants, the predryer is the greatest contributor.

It is anticipated that concentrations near the calculated 24 hour average maximum concentration will occur no more than 2 to 4% of the time in Sweetwater County, Wyoming and less than 2% of the time in Trona, California. This is estimated from the meteorological data used in the dispersion analysis. The data from Sweetwater County, Wyoming contained 6-14 days with meteorological data that resulted in concentrations within 80% of the maximum calculated concentration. The meteorological data from Trona, California contained 5 or 6 days with data of this nature.

7.1.4 Projected Growth and Particulate Emissions. Based upon production projections by the U.S. Bureau of Mines and assuming the closing of the single remaining Solvay process plant, the following growth (which would be subject to NSPS) could potentially occur by 1985:

- 1 monohydrate plant using a rotary steam tube dryer, with a production capacity of 0.454 million Mg/yr

TABLE 7-2. MAXIMUM 24-HOUR AMBIENT AIR PARTICULATE CONCENTRATIONS DUE TO EMISSIONS FROM AFFECTED SODIUM CARBONATE FACILITIES

Case No.	Control level	Facilities	Control equipment	Stack No.	Maximum downwind concentration (ug/m^3)	Distance to 24 hr maximum concentration (m)	Maximum concentrations at other distances (ug/m^3)		
							100 m	1,000 m	10,000 m
1a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	1	0.827	5,000	0.000	0.491	0.539
1a		Rotary steam tube dryer	VS	2	8.17	1,000	0.020	8.17	1.51
1a		All facilities combined		1,2	8.25	1,000	0.020	8.25	1.82
1b	Alternative 2	Coal fired calciner	C/ESP	1	0.564	5,000	0.000	0.335	0.367
1b		Rotary steam tube dryer	VS	2	1.31	1,000	0.002	1.31	0.242
1b		All facilities combined		1,2	1.36	1,000	0.002	1.36	0.572
2a	Alternative 1 (baseline)	Coal fired caliner	C/ESP	3	0.827	5,000	0.000	0.491	0.539
2a		Rotary steam tube dryer	VS	4	8.17	1,000	0.014	8.17	1.51
2a		Coal fired calciner	C/ESP	5	0.824	5,000	0.000	0.488	0.539
2a		Rotary steam tube dryer	VS	6	8.25	1,000	0.033	8.25	1.52
2a		All facilities combined		3-6	16.6	1,000	0.047	16.6	3.63
2b	Alternative 2	Coal fired calciner	C/ESP	3	0.564	5,000	0.000	0.335	0.367
2b		Rotary steam tube dryer	VS	4	1.31	1,000	0.002	1.31	0.242
2b		Coal fired calciner	C/ESP	5	0.569	5,000	0.000	0.333	0.368
2b		Rotary steam tube dryer	VS	6	1.32	1,000	0.005	1.32	0.242
2b		All facilities combined		3-6	2.73	1,000	0.007	2.73	1.14
3a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	7	0.827	5,000	0.000	0.491	0.539
3a		Fluid bed steam tube dryer	C/VS	8	5.80	1,000	0.006	5.80	1.210
3a		All facilities combined		7,8	5.94	1,250	0.006	5.88	1.71

TABLE 7-2 (continued). MAXIMUM 24-HOUR AMBIENT AIR PARTICULATE CONCENTRATIONS DUE TO EMISSIONS FROM AFFECTED SODIUM CARBONATE FACILITIES

Case No.	Control level	Facilities	Control equipment	Stack No.	Maximum downwind concentration ($\mu g/m^3$)	Distance to 24 hr maximum concentration (m)	Maximum concentrations at other distances ($\mu g/m^3$)		
							100 m	1,000 m	10,000 m
3b	Alternative 2	Coal fired calciner	C/ESP	7	0.564	5,000	0.000	0.335	0.367
3b		Fluid bed steam tube dryer	C/VS	8	0.927	1,000	0.001	0.927	0.193
3b		All facilities combined		7,8	1.13	2,000	0.001	0.978	0.554
4a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	9	0.827	5,000	0.000	0.491	0.539
4a		Fluid bed steam tube dryer	C/VS	10	5.80	1,000	0.006	5.80	1.21
4a		Coal fired calciner	C/ESP	11	0.835	5,000	0.000	0.488	0.539
4a		Fluid bed steam tube dryer	C/VS	12	5.85	1,000	0.011	5.85	1.21
4a		All facilities combined		9-12	12.0	1,250	0.015	11.8	3.41
4b	Alternative 2	Coal fired calciner	C/ESP	9	0.564	5,000	0.000	0.335	0.367
4b		Fluid bed steam tube dryer	C/VS	10	0.927	1,000	0.001	0.927	0.193
4b		Coal fired calciner	C/ESP	11	0.569	5,000	0.000	0.333	0.368
4b		Fluid bed steam tube dryer	C/VS	12	0.934	1,000	0.002	0.934	0.193
4b		All facilities combined		9-12	2.27	2,000	0.002	1.96	1.11
5a	Alternative 1 (baseline)	Rotary steam tube predryer	VS	13	7.92	550	.394	7.37	1.08
5a		Gas fired bleacher	C/ESP	14	1.96	1,000	0.002	1.96	0.292
5a		Rotary steam tube dryer	VS	15	2.89	750	0.529	2.78	0.385
5a		All facilities combined		13-15	10.4	550	0.529	10.3	1.73
5b	Alternative 2	Rotary steam tube predryer	VS	13	2.26	550	0.113	2.11	0.308
5b		Gas fired bleacher	C/ESP	14	0.653	1,000	0.001	0.653	0.097
5b		Rotary steam tube dryer	VS	15	1.45	750	0.265	1.39	0.193
5b		All facilities combined		13-15	3.43	1,000	0.265	3.43	0.590

TABLE 7-2 (continued). MAXIMUM 24-HOUR AMBIENT AIR PARTICULATE CONCENTRATIONS DUE TO EMISSIONS FROM AFFECTED SODIUM CARBONATE FACILITIES

Case No.	Control level	Facilities	Control equipment	Stack No.	Maximum downwind concentration (ug/m^3)	Distance to 24 hr maximum concentration (m)	Maximum concentrations at other distances (ug/m^3)		
							100 m	1,000 m	10,000 m
6a	Alternative 1 (baseline)	Rotary steam tube predryer	VS	16	7.92	550	0.394	7.37	1.08
6a		Gas fired bleacher	C/ESP	17	1.96	1,000	0.002	1.96	0.292
6a		Rotary steam tube dryer	VS	18	2.89	750	0.529	2.78	0.385
6a		Rotary steam tube predryer	VS	19	7.67	550	0.533	7.36	1.08
6a		Gas fired bleacher	C/ESP	20	1.93	1,000	0.005	1.93	0.296
6a		Rotary steam tube dryer	VS	21	2.91	750	0.472	2.79	0.388
6a		All facilities combined		16-21	20.8	550	1.18	20.7	3.47
6b	Alternative 2	Rotary steam tube predryer	VS	16	2.26	550	.113	2.11	0.308
6b		Gas fired bleacher	C/ESP	17	0.653	1,000	0.001	0.653	0.097
6b		Rotary steam tube dryer	VS	18	1.45	750	0.265	1.39	0.193
6b		Rotary steam tube predryer	VS	19	2.19	550	0.152	2.10	0.309
6b		Gas fired bleacher	C/ESP	20	0.642	1,000	0.002	0.642	0.099
6b		Rotary steam tube dryer	VS	21	1.46	750	0.236	1.40	0.194
6b		All facilities combined		16-21	6.83	1,000	0.498	6.83	1.10

TABLE 7-3. MAXIMUM ANNUAL AMBIENT AIR PARTICULATE CONCENTRATIONS DUE TO EMISSIONS FROM AFFECTED SODIUM CARBONATE FACILITIES

Case No.	Control level	Facilities	Control equipment	Stack No.	Maximum downwind concentration (ug/m^3)	Distance to annual maximum concentration (m)	Maximum concentrations at other distances (ug/m^3)		
							100 m	1,000 m	10,000 m
1a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	1	0.094	5,000	0.000	0.018	0.07
1a		Rotary steam tube dryer	VS	2	1.05	1.000	0.000	1.06	0.15
1a		All facilities combined		1,2	1.07	1,000	0.000	1.07	0.22
1b	Alternative 2	Coal fired calciner	C/ESP	1	0.065	5,000	0.000	0.014	0.048
1b		Rotary steam tube dryer	VS	2	0.174	1,000	0.000	0.174	0.026
1b		All facilities combined		1,2	0.191	1,250	0.000	0.186	0.074
2a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	3	0.094	5,000	0.000	0.018	0.07
2a		Rotary steam tube dryer	VS	4	1.05	1,000	0.000	1.05	0.15
2a		Coal fired calciner	C/ESP	5	0.094	5,000	0.000	0.018	0.07
2a		Rotary steam tube dryer	VS	6	1.06	1,000	0.000	1.06	0.153
2a		All facilities combined		3-6	2.15	1,000	0.000	2.15	0.44
2b	Alternative 2	Coal fired calciner	C/ESP	3	0.065	5,000	0.000	0.014	0.048
2b		Rotary steam tube dryer	VS	4	0.174	1,000	0.000	0.174	0.026
2b		Coal fired calciner	C/ESP	5	0.065	5,000	0.000	0.014	0.048
2b		Rotary steam tube	VS	6	0.174	1,000	0.000	0.174	0.026
2b		All facilities combined		3-6	0.382	1,250	0.000	0.372	0.148
3a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	7	0.094	5,000	0.000	0.018	0.07
3a		Fluid bed steam tube dryer	C/VS	8	0.70	1,250	0.000	0.66	0.14
3a		All facilities combined		7,8	0.725	1,250	0.000	0.68	0.21

TABLE 7-3. (continued). MAXIMUM ANNUAL AMBIENT AIR PARTICULATE CONCENTRATIONS DUE TO EMISSIONS FROM AFFECTED SODIUM CARBONATE FACILITIES

Case No.	Control level	Facilities	Control equipment	Stack No.	Maximum downwind concentration (ug/m^3)	Distance to annual maximum concentration (m)	Maximum concentrations at other distances (µg/m^3)		
							100 m	1,000 m	10,000 m
3b	Alternative 2	Coal fired calciner	C/ESP	7	0.065	5,000	0.000	0.014	0.048
3b		Fluid bed steam tube dryer	C/VS	8	0.114	1,250	0.000	0.108	0.024
3b		All facilities combined		7,8	0.145	2,000	0.000	0.122	0.072
4a	Alternative 1 (baseline)	Coal fired calciner	C/ESP	9	0.094	5,000	0.000	0.018	0.07
4a		Fluid bed steam tube dryer	C/VS	10	0.70	1,250	0.000	0.66	0.14
4a		Coal fired calciner	C/ESP	11	0.094	5,000	0.000	0.018	0.07
4a		Fluid bed steam tube dryer	C/VS	12	0.70	1,250	0.000	0.67	0.14
4a		All facilities combined		9-12	1.45	1,250	0.000	1.36	0.421
4b	Alternative 2	Coal fired calciner	C/ESP	9	0.065	5,000	0.000	0.014	0.048
4b		Fluid bed steam tube dryer	C/VS	10	0.114	1,250	0.000	0.108	0.024
4b		Coal fired calciner	C/ESP	11	0.065	5,000	0.000	0.014	0.048
4b		Fluid bed steam tube dryer	C/VS	12	0.114	1,250	0.000	0.108	0.024
4b		All facilities combined		9-12	0.291	2,000	0.000	0.244	0.144
5a	Alternative 1 (baseline)	Rotary steam tube predryer	VS	13	0.604	1,000	0.003	0.604	0.134
5a		Gas fired bleacher	C/ESP	14	0.139	1,000	0.000	0.139	0.039
5a		Rotary steam tube dryer	VS	15	0.244	1,000	0.011	0.244	0.049
5a		All facilities combined		13-15	0.946	1,000	0.011	0.946	0.222
5b	Alternative 2	Rotary steam tube predryer	VS	13	0.173	1,000	0.001	0.173	0.038
5b		Gas fired bleacher	C/ESP	14	0.046	1,000	0.000	0.046	0.013
5b		Rotary steam tube dryer	VS	15	0.122	1,000	0.005	0.122	0.024
5b		All facilities combined		13-15	0.330	1,000	0.005	0.330	0.076

TABLE 7-3. (continued). MAXIMUM ANNUAL AMBIENT AIR PARTICULATE CONCENTRATIONS DUE TO EMISSIONS FROM AFFECTED SODIUM CARBONATE FACILITIES

Case No.	Control level	Facilities	Control equipment	Stack No.	Maximum downwind concentration (ug/m^3)	Distance to annual maximum concentration (m)	Maximum concentrations at other distances ($\mu g/m^3$)		
							100 m	1,000 m	10,000 m
6a	Alternative 1 (baseline)	Rotary steam tube predryer	VS	16	0.604	1,000	0.003	0.604	0.134
6a		Gas fired bleacher	C/ESP	17	0.139	1,000	0.000	0.139	0.039
6a		Rotary steam tube dryer	VS	18	0.244	1,000	0.011	0.244	0.049
6a		Rotary steam tube predryer	VS	19	0.600	1,000	0.005	0.60	0.135
6a		Gas fired bleacher	C/ESP	20	0.140	1,000	0.000	0.140	0.039
6a		Rotary steam tube dryer	VS	21	0.244	1,000	0.010	0.244	0.049
6a		All facilities combined		16-21	1.90	1,000	0.021	1.90	0.445
6b	Alternative 2	Rotary steam tube predryer	VS	16	0.173	1,000	0.001	0.173	0.038
6b		Gas fired bleacher	C/ESP	17	0.046	1,000	0.000	0.046	0.013
6b		Rotary steam tube dryer	VS	18	0.122	1,000	0.005	0.122	0.024
6b		Rotary steam tube predryer	VS	19	0.172	1,000	0.001	0.172	0.039
6b		Gas fired bleacher	C/ESP	20	0.047	1,000	0.000	0.047	0.013
6b		Rotary steam tube dryer	VS	21	0.122	1,000	0.005	0.122	0.025
6b		All facilities combined		16-21	0.662	1,000	0.010	0.662	0.152

TABLE 7-4. COMPARISON OF MAXIMUM AMBIENT AIR CONCENTRATIONS (ug/m^3) DUE TO EMISSIONS FROM MODEL SODIUM CARBONATE PLANTS

Model Plant Number	Facilities	Control Equipment	Maximum 24 hour Concentration[a]		%reduction Alt. 1 to Alt. 2	Average annual concentration[a]		%reduction Alt. 1 to Alt. 2
			Alt. 1	Alt. 2		Alt. 1	Alt. 2	
1	Coal fired calciner	C/ESP	8.25	1.36	83.5	1.07	0.191	82.1
	Rotary steam tube dryer	VS						
2	Coal fired calciner	C/ESP	16.6	2.73	83.6	2.15	0.382	82.2
	Rotary steam tube dryer	VS						
3	Coal fired calciner	C/ESP	5.94	1.13	81.0	0.725	0.145	80.0
	Fluid bed dryer	C/VS						
4	Coal fired calciner	C/ESP	12.0	2.27	81.0	1.45	0.291	79.9
	Fluid bed dryer	C/VS						
5	Rotary steam heated predryer	VS	10.4	3.43	67.0	0.946	0.330	65.1
	Gas fired bleacher	C/ESP						
	Rotary steam tube dryer	VS						
6	Rotary steam heated predryer	VS	20.8	6.83	67.2	1.90	0.662	65.1
	Gas fired bleacher	C/ESP						
	Rotary steam tube dryer	VS						

[a] Includes emissions from all affected facilities

- 1 monohydrate plant using a fluid bed steam tube dryer, with production capacity of 0.454 million Mg/yr
- 1 direct carbonation plant, with a production capacity of 0.454 million Mg/yr.

There is not expected to be any replacement of existing facilities. This growth scenario is used to provide an estimate of the potential long-range national impacts of Alternative 2.

Table 7-5 summarizes the national particulate emissions from new and existing sodium carbonate plants projected for the year 1985 under the regulatory alternatives. Under Alternative 1, particulate emissions from the affected facilities in new sodium carbonate plants would reach 444 to 696 Mg/yr (490 to 768 TPY) by 1985. The lower value for projected emissions is based on Wyoming's BACT requirement, and the higher value is based on the process weight regulation, as discussed in Section 3.3. Under Alternative 2, these emissions would be reduced to 278 Mg/yr (307 TPY). Alternative 2 thus represents a decrease in particulate emissions ranging from 166 to 420 Mg/yr (183 to 461 TPY).

7.1.5 Secondary Air Quality Impacts

Secondary air pollutants are pollutants generated as a result of applying the control equipment. There are no air pollutants generated directly by the control equipment used to achieve each control level. There is, however, an increase in power plant emissions caused by the additional electrical demand of the control equipment.

In the worst case (for a fluid bed dryer) the increase in particulates generated at the power plant in switching from Alternative 1 to Alternative 2 is 0.0012 kg/Mg dry product.[6] The increase in removal of sodium carbonate particulates caused by this action is 0.21 kg/Mg dry product. These incremental power plant emissions of .0012 kg/Mg dry product reduce the additional particulate removal of the control alternative level to 0.209 kg/Mg dry product, which is less than a one percent impact. The increased power plant emissions would have an even smaller impact for the other facilities.

TABLE 7-5. PROJECTED NATIONAL EMISSIONS FROM SODIUM CARBONATE PLANTS FOR 1985

Plant	Processing Configuration[b]	Alt. 1[e]		Alt. 2	
		Mg/yr[a]	TPY	Mg/yr	TPY
Monohydrate (w/rotary steam tube dryer)	1	251	275	107	117
Monohydrate (w/fluid bed steam tube dryer)	2	251	275	107	117
Direct carbonation	3	198	218	66.3	73
Total new plant emissions[c]		700	768	280	307
Estimated existing plant emissions[d]		6108	6737	6108	6737
Total national emissions		6808	7505	6388	7044

[a] Based on 7446 operating hours per year, and the process weight regulation for Alt. 1.

[b] As defined in Chapter 6.

[c] New plants are defined as plants beginning construction after 1980 and subsequently affected by the New Source Performance Standard.

[d] Existing plants are defined as including plants beginning construction prior to 1980 and subsequently unaffected by the New Source Performance Standard.

[e] Alt. = Alternative

7.1.6 Summary of Air Quality Impacts

The primary air pollutant emissions from affected facilities in the sodium carbonate industry are particulates, but other emissions include organics and combustion gases. The major benefit of implementing control alternative 2 is a reduction of particulate emissions, and thus a potential lessening of health and ecological hazards. National emissions could potentially be reduced by 420 megagrams/yr in 1985 by going from Alternative 1 to Alternative 2. Ambient air concentrations in the vicinity of a new plant are projected to be reduced by about 80 percent for a monohydrate plant, and by about 65 percent for a direct carbonation plant by implementing Alternative 2 instead of Alternative 1.

7.2 WATER POLLUTION IMPACT

The only emission control equipment which potentially results in a wastewater stream is the venturi scrubber. The scrubber effluent is a solution of sodium salts that will be at or near saturation and may even contain some undissolved sodium salts.

Venturi scrubber effluents will have almost no impact on water effluents from the plant since each scrubber discharge is similar to many of the process streams and can be rerouted to the process with very little impact. Scrubber effluent from product dryers is returned to the crystallizer where valuable sodium carbonate can be recovered.[7] The discharge from the predryer venturi scrubber may be combined with the exit stream of the bicarbonate dryer scrubber. This combined stream is then used as a filter cake wash. The effluent from the cake washing is returned to the lake salt structure to dissolve lake deposits and is eventually recycled to the plant.

The volume and composition of scrubber effluent streams is about the same for the different regulatory alternatives. There is no difference in the water pollution impacts of the different alternatives.

7.3 SOLID WASTE IMPACT

There are no solid wastes generated by the application of particulate control equipment to the affected facilities. The particulates removed can be reclaimed as product or used to produce additional product.

For calciner and bleacher ESP's Alternative 2 would result in the removal of 44 Mg/yr (calciner) and 24 Mg/yr (bleacher) additional particulates over Alternative 1. The amount of particulates removed in cyclones is the same for either Alternative; the difference in particulate removal occurs in the ESP or venturi scrubber following the cyclone. The particulates removed in venturi scrubbers were considered in Section 7.2, Water Pollution Impact, since they are contained in an aqueous effluent stream.

The particulates removed from the calciner exhausts are returned to the dissolvers along with the other calcined ore. The solids removed by the cyclone on the predryer exhaust are combined with the predryer product and sent to the bicarbonate dryers. The particulates removed in the bleacher cyclone are returned to the bleacher feed. The particulates removed by the bleacher ESP can be sent to the monohydrate crystallizers or combined with a liquid waste stream and eventually returned to the lake salt structure.

The particulates collected by the cyclone on the fluid bed dryers are combined directly with the dried product. The particulates removed are very fine and may adversely affect product quality. There is, however, no difference in impact between the two alternatives since the quantity of particulates removed in the cyclone is the same for both alternatives.

There are many practical methods for recycling the collected particulates. In doing this the plants recover a valuable product and avoid any potential solid waste problem which may have developed.

7.4 ENERGY IMPACT

7.4.1 Primary Energy Requirements

The emission control equipment for the sodium carbonate industry uses electrical energy. The fans and pumps of the control systems are the primary energy consumers. Electrostatic precipitators require electricity to maintain a collecting field and rap the collection plates.

The energy requirements of the control equipment for each control alternative and for the emission sources are presented in Table 7-6. The incremental increase in energy consumption from Alternative 1 to Alternative 2 on a yearly basis is also shown. The largest increase is for a fluid

TABLE 7-6. ENERGY REQUIREMENTS FOR MODEL FACILITIES AND CONTROL EQUIPMENT IN THE SODIUM CARBONATE INDUSTRY

Facility	Control[a] Equipment	Energy required for facility operation[b,c] MJ/kg feed (10^6 Btu/ton feed)	Energy required for control equipment operation[c,d] MJ/kg feed (10^6 Btu/ton feed)		Incremental control[e] equipment energy usage for Alt. 2 vs. Alt. 1 TJ/yr (10^{10} Btu/yr)
			Alt. 1	Alt. 2	
Coal fired calciner	C/ESP	1.8 (1.5)	0.0949 (0.0816)	0.102 (0.0878)	6.2 (0.561)
Rotary steam tube dryer	VS[f] (Wyoming)	0.91 (0.79)	0.0206 (0.0177)	0.0498 (0.0428)	17.8 (1.67)
	VS[f] (Calif.)	0.91 (0.79)	0.0292 (0.0251)	0.0429 (0.0369)	7.85 (0.739)
Fluid bed steam tube dryer	C/VS	0.97 (0.84)	0.0515 (0.0443)	0.127 (0.109)	46.8 (4.40)
Rotary steam tube predryer	VS	0.29 (0.25)	0.031 (0.027)	0.050 (0.043)	16 (1.5)
Bleacher	C/ESP	0.22 (0.19)	0.0208 (0.0179)	0.0226 (0.0194)	0.92 (0.0871)

[a] C/ESP - cyclone/electrostatic precipitator, VS - venturi scrubber, C/VS - cyclone/venturi scrubber

[b] Including thermal and electrical requirements. Steam generating efficiency, electrical generating efficiency, and line losses were taken into account. Electrical generating efficiency was assumed to be 34 percent with approximately a 10 percent line loss. Overall steam generating efficiency (including line loss) was assumed to be 85 percent.

[c] Feed rates and compositions are reported in Table 6-2.

[d] Based on fan and pump requirements; ESP requirements were added where necessary. Electrical generating efficiency was assumed to be 34 percent with a line loss of about 10 percent.

[e] Based on 7,446 operating hours per year and production of 0.454 million Mg/yr sodium carbonate.

[f] Discrimination between states accounts for varying climatic and elevation factors and different baseline levels.

bed dryer using a cyclone/venturi scrubber control system. For this case the energy increase in going from Alternative 1 to Alternative 2 is 0.0757 MJ/kg product. This is equivalent to 11 percent of the net facility consumption, but only 1.2 percent of the energy consumption of the entire plant.

7.4.2 Projected Energy Requirements

The same growth scenario used in Section 7.1.3 to project the national air impact for 1985 was used to project the national energy impact. Table 7-7 summarizes the energy usage for each of the new plants, giving the total energy requirement of the affected facilities and of the control equipment for the alternative control levels. Also presented is the incremental increase caused by going to Alternative 2 from Alternative 1. The total national energy increase created by implementing control Alternative 2 as opposed to Alternative 1 is 107 TJ/yr (10.2×10^{10} Btu/yr), or 1.73×10^{4} barrels of oil per year.

7.5 OTHER IMPACTS

The only other potential impact is the generation of noise by the control equipment. The primary sources of noise from the control equipment are the fans. The emission sources generate noise during combustion (calciner, bleacher), cleaning (predryers), the intake of air (fluid bed dryer fans, predryer fan and heat exchanger), and by the escape of steam (rotary steam tube dryers). Compared to these existing noise sources of the affected facilities, the noise generated by the fans associated with the control equipment is small. There is a small increase in fan size at the alternative control levels over the baseline, but the increase in noise levels between these fans is only slight, if any.

7.6 OTHER CONCERNS: COMMITMENT OF NATURAL RESOURCES

A potential concern associated with increasing emission control levels from the baseline level to the control alternative is the quantity of water needed to operate a venturi scrubber. Although the scrubbing liquor is recycled to the process, a certain percentage must be replaced to make up for water evaporated from the venturi into the stack gas. However, there is no difference between the makeup water demand of the two alternatives. The quantity of water absorbed by the stack

TABLE 7-7. ENERGY REQUIREMENTS OF PROJECTED SODIUM CARBONATE PLANTS (TJ/yr (10^{10} Btu/yr))[a,b]

Plant	Facility	Control equipment	Energy required for facility operation[c]	Energy required for control equipment operation		Incremental increase from Alternative to Alternative 2
				Alternative 1	Alternative 2	
Monohydrate	Coal-fired calciner	C/ESP	1500 (150)	83 (7.9)	90 (8.5)	7 (0.6)
	Rotary steam tube dryer	VS	560 (53)	13 (1.2)	31 (2.9)	18 (1.7)
	Total for facilities			96 (9.1)	121 (11.4)	25 (2.3)
Monohydrate	Coal-fired calciner	C/ESP	1500 (150)	83 (7.9)	90 (8.5)	7 (0.6)
	Fluid bed steam tube dryer	C/VS	600 (56)	32 (3.0)	78 (7.4)	46 (4.4)
	Total for facilities			115 (10.9)	168 (15.9)	53 (5.0)
Direct carbonation	Predryer	VS	250 (24)	27 (2.6)	44 (4.1)	16 (1.5)
	Bleacher	C/ESP	130 (13)	13 (1.2)	14 (1.3)	1 (0.1)
	Rotary steam tube dryer	VS	560 (53)	18 (1.7)	26 (2.5)	8 (0.8)
	Total for facilities			58 (5.5)	84 (7.9)	25 (2.4)
New source total			5100 500	269 (25.5)	373 (35.2)	103 (9.7)

[a] Based on 7446 operating hours/year and production of 0.454 million Mg/yr (0.5 million TPY) sodium carbonate.

[b] Typical energy usage for an entire sodium carbonate plant using the monohydrate process is 3690 TJ/yr (350 x 10^{10} Btu/yr).

[c] Includes thermal and electrical requirements. Steam generating efficiency, electrical generating efficiency, and line losses were taken into account. Electrical generating efficiency was assumed to be 34 percent with approximately a 10 percent line loss. Overall steam generating efficiency (including line loss) was assumed to be 85 percent.

gas is based on the gas flow and other gas parameters, which are the same at both control levels. Thus, there would be no additional commitment of water resources due to the promulgation of Alternative 2 over Alternative 1.

7.7 REFERENCES

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2. Environmental Protection Agency, Emission Measurement Branch. Emission Test Program: Sodium Carbonate Manufacturing Plant Conducted at FHC Corporation, March 11, 1980, EMB Report 79-SOD-2.
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5. Wyoming Department of Environmental Quality, Division of Air Quality. Particulate Stack Sampling Reports for Allied, FMC, Stauffer, and Texasgulf Sodium Carbonate Plants.
6. Memo from David R. Pierce, Radian Corporation, to Docket. October 8, 1979. Increased Power Plant Emissions.
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8. ECONOMIC IMPACTS

8.1 INDUSTRY CHARACTERIZATION

8.1.1 General Profile

As of March 1979, there were eight sodium carbonate plants in the United States with a total capacity of approximately 8.5 million Mg/year (9.3 million TPY). The ownership, location, startup date, capacity, and process type for each of the eight plants are presented in Table 8-1. Employment data for the industry are also presented. There are no major byproducts from any of the sodium carbonate processes; however, additional products are produced concurrently in certain plants. Kerr-McGee produces sodium sulfate, and borax and potash products, as well as sodium carbonate. FMC Corporation produces small amounts of sodium tripolyphosphate at its sodium carbonate plant, and Allied Chemical produces a variety of inorganic chemicals at its Syracuse location. Production methods for soda ash are classified as either synthetic or natural. Synthetic production has declined sharply since the mid-1960's, and only one synthetic plant is currently (August 1979) in operation.

The natural processes use either trona ore (an ore containing sodium sesquicarbonate) or a brine solution containing sodium sesquicarbonate as a raw material. Major natural deposits of trona are located near Green River, Wyoming, and at Searles Lake, California. All plants using a natural process are located near one of these deposits. In Wyoming, estimated resources of halite-free trona are 29 billion megagrams (32 billion tons).[1] These represent about 13 billion megagrams (14 billion tons) of sodium carbonate, or at 1977 levels of total domestic demand, about a 1900 year supply. In addition, Wyoming deposits contain about 77 billion megagrams (85 billion tons) of less pure trona.[1] Mining rights to the trona ore reserves near Green River are granted by the federal and state governments and by the Union Pacific Railroad. Sodium carbonate resources at Searles Lake, California, are estimated at 145 million megagrams (160 million tons).[2] Mining rights to these deposits are granted by the federal and state governments.

Three types of natural processes, the monohydrate, the sesquicarbonate,

TABLE 8-1. THE DOMESTIC SODIUM CARBONATE INDUSTRY

Owner	Plant Name	Location	Startup Date[a]	Capacity		Process type	Employment
				10^6 Mg/yr	(TPY)		
Kerr-McGee	Trona	Trona, CA	1978[d]	1.2	(1.3)	Direct carbonation	3600[c]
	West End	Trona, CA	f	0.14	(0.15)	Direct carbonation	
Allied Chem.	Trona	Green River, WY	1968	2.0	(2.2)	Monohydrate	
FMC Corp.	Westvaco	Green River, WY	1972	1.13	(1.25)	Monohydrate	
			1947	1.13	(1.25)	Sesquicarbonate	
Stauffer Chem.	Big Island	Green River, WY	1962	1.54	(1.65)	Monohydrate	
Texasgulf, Inc.		Green River, WY	1976	0.91	(1.0)	Monohydrate	
Allied Chem.		Syracuse, NY	1881	0.8	(0.9)	Solvay (synthetic)	1800[e]

[a] Startup dates are for the original plant unless otherwise stated. See Table 8-6 for expansion dates. Reference 3.

[b] Capacity data, with the exception of Kerr-McGee's Trona plant are valid through March, 1979. The value for Kerr-McGee's Trona Plant is a planned capacity for year-end 1979.

[c] Value includes employment for mine and plant. 1978 value. Reference 1.

[d] Kerr-McGee operated a small plant at this location prior to 1978. However, most of the reported capacity was added in 1978. Reference 1.

[e] Employment value is for the entire plant, which produces calcium chloride, chlorine, caustic soda, sodium nitrite, ammonium chloride, and sodium sesquicarbonate in addition to soda ash. 1978 value. Reference 4.

[f] Kerr-McGee purchased this plant from Stauffer Chemical Co. in 1974. Actual plant startup was not determined.

and the direct carbonation, are currently used. The direct carbonation process involves the processing of a sodium sesquicarbonate containing brine, and the monohydrate and sesquicarbonate processes involve the processing of trona ore. Deposits in Wyoming are well suited for processing by either the monohydrate or sesquicarbonate processes. California deposits are better suited for processing by the direct carbonation process.

Both the direct carbonation and the monohydrate process produce a product with a density of 960 kg/m^3 (60 lbs/ft^3) directly. The sesquicarbonate process produces a product with a density of 800 kg/m^3 (50 lbs/ft^3) directly, and secondary calcining is required to raise its density to 960 kg/m^3 (60 lbs/ft^3).

Synthetic sodium carbonate is produced in two grades, known as Light Ash and Dense Ash. The differences between the two grades are physical only. The density of Light Ash is between 560 and 740 kg/m^3 (35 and 46 lbs/ft^3), while the density for Dense Ash is between 1100 and 1200 kg/m^3 (68 and 78 lbs/ft^3). The glass industry, the largest consumer of sodium carbonate, prefers the Dense Ash, while the chemical industry, another major consumer, prefers the Light Ash.

The approximate percentages of sodium carbonate usage by the various consumers during 1978 are presented in Table 8-2. The breakdown for 1978 is fairly typical of sodium carbonate usage during previous years. The most significant change over the last five years is that exports are beginning to take a larger share of production. This is further discussed in Section 8.1.2.5.

Caustic soda is the only product which can be substituted for sodium carbonate to any significant extent. Caustic soda can be substituted for sodium carbonate in the chemicals, pulp and paper, cleaning agents, and water treatment industries. These currently amount to roughly 40 percent of the sodium carbonate markets. At present, neither caustic soda nor sodium carbonate seems to have a distinct competitive advantage over the other.[5]

Imports in 1978 are estimated to have been only 7 thousand megagrams (8 thousand tons).[1] Exports in 1978 reached 660 thousand megagrams[1] (724 thousand tons), or as indicated in Table 8-2, roughly 9 percent of domestic production.

TABLE 8-2. USES OF SODIUM CARBONATE (1978)

Use	Percent of Total Domestic Production
Glass	~50
Chemicals	~25
Pulp and Paper, Cleaning Agents, Water Treatment, and Other	~16
Exports	~9

~Indicates an approximate value

Reference 1.

8.1.2 Trends

8.1.2.1 Historical Trends In the Method of Production. A yearly breakdown of the domestic production of sodium carbonate for the years 1967 through 1978 is given in Table 8-3. Perhaps the most significant trend seen in this table is the rapid decline in the synthetic (Solvay process) production of sodium carbonate, and the correspondingly rapid increase in the natural production. Increasing fuel costs combined with stricter water pollution laws have made it difficult for synthetic producers to compete with natural producers. Also, the construction of a Solvay plant generally requires a greater capital investment.

Associated with the shift in the primary method of sodium carbonate production has been the closing of synthetic plants and the startup and subsequent expansions of several natural sodium carbonate plants. In 1967 there were ten synthetic sodium carbonate plants, having a combined capacity of 5.0 million Mg/year (5.5 million TPY). As noted in Section 8.1.1, there in only one synthetic plant presently in operation.

The first closing of those synthetic plants in existence in 1967 occurred in 1969. A yearly breakdown of the closing of plants from 1969 through 1978 is presented in Table 8-4. Eight of these plants had capacities of either about 0.32 million Mg/year (0.34 million TPY) or 0.73 million Mg/year (0.80 million TPY). The Dow Chemical Plant, with a capacity of 0.16 million Mg/year (0.18 million TPY), produced sodium carbonate by the direct carbonation of caustic.

Three natural sodium carbonate plants were operating in 1967. By 1979 this number had increased to seven. Natural sodium carbonate plants typically consist of a combination of trains, each having a capacity of approximately 0.45 million Mg/year (0.50 million TPY). The trains can be thought of as independent and complete processing units. Table 8-5, which lists plant capacities by year from 1967 through 1979, indicates when start-ups and expansions occurred. Table 8-5 also indicates the size of the new plants and of the expansions in capacity. Generally, from the expansion

TABLE 8-3. DOMESTIC SODIUM CARBONATE PRODUCTION (1967-1978)[a]

Year	Production						Percent change from previous year	Percent of total from natural production
	Synthetic		Natural		Total			
	10^3 mg/yr	(10^3 TPY)	10^3 mg/yr	(10^3 TPY)	10^3 mg/yr	(10^3 TPY)		
1967	4399	(4849)	1566	(1726)	5965	(6575)	-3.4	26.3
1968	4169	(4596)	1853	(2043)	6022	(6639)	+1.0	30.8
1969	4118	(4540)	2263	(2495)	6381	(7035)	+6.0	35.5
1970	3986	(4393)	2430	(2678)	6416	(7071)	+0.5	37.9
1971	3899	(4298)	2600	(2865)	6499	(7163)	+1.3	40.0
1972	3906	(4305)	2919	(3218)	6825	(7523)	+5.0	42.8
1973	3459	(3813)	3377	(3722)	6836	(7535)	+0.2	49.4
1974	3181	(3507)	3682	(4059)	6863	(7566)	+0.4	53.6
1975	2542	(2802)	3927	(4328)	6469	(7130)	-5.8	60.7
1976	2127	(2344)	4732	(5216)	6859	(7560)	+6.0	69.0
1977	1644	(1812)	5650	(6228)	7294	(8040)	+6.3	77.5
1978	1145[b]	(1262)	6153[c]	(6782)	7298[b]	(8044)	~0.0	84.3[b]

[a] 1967-1975 Reference 6; 1976-1977 Reference 1.

[b] Estimate.

[c] 1978 Reference 7.

TABLE 8-4. SYNTHETIC SODIUM CARBONATE PLANT SHUTDOWNS (1967-1978)[a]

Year	Company	Location	Capacity	
			10^6 Mg/year	(10^6 TPY)
1969	Allied Chemical	Detroit, Michigan	0.36	(0.4)
1970	Dow Chemical	Freeport, Texas	0.16	(0.18)
1971	Olin Chemical	Saltsville, Virginia	0.36	(0.375)
1973	PPG Industries	Barberton, Ohio	0.5	(0.6)
1975	Olin Chemical	Lake Charles, Louisiana	0.32	(0.35)
	Allied Chemical	Baton Rouge, Louisiana	0.7	(0.8)
1976	Diamond Shamrock	Painesville, Ohio	0.7	(0.8)
1978	PPG Industries	Corpus Christi, Texas	0.27	(0.3)
	BASF-Wyandotte	Wyandotte, Michigan	0.7	(0.8)

[a] Reference 8.

TABLE 8-5. PLANT CAPACITIES BY YEAR FOR THE NATURAL SODIUM CARBONATE INDUSTRY (1967-1979)[a]

Owner	Location	10^6 Mg/year												
		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Kerr-McGee	Trona, CA	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.86	1.2[e]
	Trona, CA								0.14[b]	0.14	0.14	0.14	0.14	0.14
Allied Chem.	Green River, WY			0.50	0.50	0.50	0.50	1.0	1.0	1.0	2.0	2.0	2.0	2.0
FMC Corp.	Green River, WY						0.45	0.45	0.45	0.45	1.13	1.13	1.13	1.13
		1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Stauffer Chem.	Green River, WY	0.91	0.91	0.91	0.91	0.91	1.36	1.36	1.36	1.36	1.36	1.54	1.54	1.54
Texasgulf, Inc.	Granger, WY										0.91	0.91	0.91	0.91
PPG Industries	CA	c	closed[d]											
Stauffer Chem.	CA		0.14	0.14	0.14	0.14	0.14	0.14	b					

[a] 1967-1976 Reference 9.
1977 Reference 10.
1978-1979 Reference 1.

[b] Kerr-McGee purchased this plant from Stauffer Chemical in 1974.

[c] This value was not found; however, it is believed to be small.

[d] The author is not certain this plant was actually closed. It may have been sold to Stauffer Chemical.

[e] Kerr-McGee plans to shut down 0.13 X 10^6 Mg/year of capacity during 1979 in addition to adding 0.45 X 10^6 Mg/year of new capacity. The listed value is the final capacity which the plant will have after these changes. Reference 11.

TABLE 8-5. PLANT CAPACITIES BY YEAR FOR THE NATURAL SODIUM CARBONATE INDUSTRY (1967-1979)[a]

Owner	Location	10^6 Tons/yr.												
		1967	1968	1979	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Kerr-McGee	Trona, CA	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.94	1.3[e]
									0.15[b]	0.15	0.15	0.15	0.15	0.15
Allied Chem.	Green River, WY			0.55	0.55	0.55	0.55	1.1	1.1	1.1	2.2	2.2	2.2	2.2
FMC Corp.	Green River, WY						0.5	0.5	0.5	0.5	1.25	1.25	1.25	1.25
		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Stauffer Chem.	Green River, WY	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.7	1.7	1.7
Texasgulf, Inc.	Granger, WY										1.0	1.0	1.0	1.0
PPG Ind.	CA	c	closed[d]											
Stauffer Chem.	CA		0.15	0.15	0.15	0.15	0.15	0.15	b					

[a] 1967-1976 Reference 9.
1977 Reference 10.
1978-1979 Reference 1.

[b] Kerr-McGee purchased this plant from Stauffer Chemical in 1974.

[c] This value was not found; however, it is believed to be small.

[d] The author is not certain this plant was actually closed. It may have been sold to Stauffer Chemical.

[e] Kerr-McGee plans to shut down 0.14 X 10^6 TPY of capacity during 1979 in addition to adding 0.50 X 10^6 TPY of new capacity. The listed value is the final capacity which the plant will have after these changes. Reference 11.

size, the number of trains added can be determined. For example, Allied Chemical added one train in 1973, and Stauffer added one train in 1972. Stauffer's expansion in 1977 was only 0.18 million Mg/year (0.2 million TPY), which is too small to be a complete train. This expansion was a result of equipment modification in the existing plant along with the addition of some new equipment.[12]

8.1.2.2 Historical Trends In The Geographical Distribution Of Plants. The closing of synthetic plants and the opening of natural sodium carbonate plants in Wyoming and California resulted in a relatively rapid change in the geographical distribution of sodium carbonate production. Unlike trona ore deposits, supplies of salt and limestone, the primary raw materials of the Solvay process, are relatively well distributed. The nine Solvay plants operating in 1967 were located in six states as follows: two in Louisiana, two in Michigan, two in Ohio, one in Texas, one in New York, and one in Virginia. While these plants were in operation they had the advantage of being closer to the markets than the natural producers in Wyoming.

Practically all sodium carbonate from producers in Wyoming is shipped by rail. The volume rate of production makes shipment by truck impractical. A railroad strike or a shortage of rail cars can have serious, but probably short term, detrimental effects on the sodium carbonate industry in Wyoming.[13] Heavy winter storms can also cause temporary transportation problems.

One benefit of the Wyoming location is the availability of large coal supplies. Recent expansions and new plants have been designed to burn coal as the primary fuel. Future expansions and new plants will probably be designed to burn coal also.

8.8.2.3 Historical And Future Trends In Production. The average annual growth rate in total sodium carbonate production between 1967 and 1977 was 2.0 percent per year. This is only slightly higher than that of the 30 years through 1974 during which it was 1.6 percent per year.[14] Historically, the growth in sodium carbonate production rate has been slow but relatively stable. Projected annual growth rates in production from 1976 through 1985 and from 1976 through 2000 are 3.0 percent and 2.6 percent respectively. These growth rates represent a slight increase in the growth rate of annual sodium carbonate production over that of previous years. Projected U. S. demand and production for the years 1985 and 2000 are presented in Table 8-6. Extrapolated production, based on previous trends, is also contained in this table. Projections were made by the U.S. Bureau of Mines by analyzing past records and making correlations with common economic indicators. Known factors likely to influence or distort the projections were taken into account. Two of the more significant of these factors are the caustic soda market and the export market. (A more thorough explanation of how the projections were made may be obtained from Dennis Kostick of the U.S. Bureau of Mines, Division of Nonmetallic Minerals.)

8.1.2.4 Competition With Caustic. As noted in Section 8.1.1, sodium carbonate is subject to competition with caustic soda in what presently amounts to roughly 40 percent of its markets. Until 1975 caustic had a distinct advantage in these markets. In 1975, caustic prices rose enough to seriously damage its ability to compete with sodium carbonate. The reasons behind the 1975 price increases are presented in a 1976 publication by the Executive Office of the President, Council on Wage and Price Stability, entitled A Study of Chlorine, Caustic Soda Prices.[16] Recently, the prices of caustic have become more competitive so now neither caustic nor sodium carbonate holds a distinct advantage.

The ability of sodium carbonate to compete with caustic is dependent upon its relative cost of production. A significant percentage of the total cost of production for both caustic soda and sodium carbonate is due to energy costs. Approximately 7.3×10^9 joules (6.9×10^6 BTU) of energy are required to produce one megagram (1.102 tons) of sodium carbonate by the monohydrate process (the most commonly used of the natural processes). The electrolytic production of an equivalent amount of caustic, .754 megagrams (0.831 tons) (using sodium oxide, Na_2O, as a common denominator), requires approximately 1.5×10^{10} joules (1.4×10^7 BTU) of energy.[25] However, this includes the co-production of .685 megagrams (0.755 tons) of chlorine.

The market for chlorine has a strong influence on the competitiveness of caustic soda. Generally, when the demand and production of chlorine is

TABLE 8-6. PROJECTED U.S. DEMAND AND PRODUCTION OF SODIUM CARBONATE FOR 1985 AND 2000

Year	Demand		Extrapolated production[a]		Projected production[b]	
	10^3 Mg/yr	(10^3 TPY)	10^3 Mg/yr	(10^3 TPY)	10^3 Mg/yr	(10^3 TPY)
1985	7900	(8700)	8300	(9100)	9000	(9900)
2000	11,500	(12,700)	10,200	(11,200)	12,660	(13,950)

[a] Extrapolated from previous trends.

[b] Based on past records and common economic indicators.

Reference 15.

high, the amount of available caustic is high enough that it can be priced to compete with soda ash. The expected outlook for the future is that caustic will continue to be a strong competitor with sodium carbonate; however, competition from caustic is not expected to have any serious detrimental impact on future sodium carbonate demand.[8]

8.1.2.5 Exports and Imports. Most sodium carbonate production outside the U.S. is by the Solvay process. Known trona deposits in other countries are relatively small, and the U.S. is the only significant producer of natural sodium carbonate. It is conceivable that environmental issues could lead to the closing of a number of Solvay plants in the industrialized nations of Europe or Asia. If this occurs, these countries may increase their imports of U.S. sodium carbonate, and this increase would have a strong positive influence on the industry in this country. As of this writing, there does not seem to be much of a movement to close Solvay plants in Europe or Asia.[15]

At present, U.S. sodium carbonate has difficulty competing in the West European market with sodium carbonate from Eastern Europe. Some countries in Western Europe feel that Eastern Europe is dumping sodium carbonate, or selling it below production costs. It is being sold at a relatively low price, which hurts domestic producers in Western Europe. Some type of trade protection by the governments of West European countries may result. The potential effects on future U.S. exports to these countries is uncertain.

Annual exports between 1967 and 1978 are presented in Table 8-7. The growth rate in annual exports has been relatively strong over the past 10 years, and this rate has outstripped the growth rate in annual production. Projections of exports were not found. Therefore, future exports were estimated by taking the differences between projected production and demand for the years 1985 and 2000. These differences are 1.09 million megagrams (1.20 million tons) for 1985, or 12.1 percent of production, and 1.13 million megagrams (1.25 million tons) for 2000, or 8.9 percent of production. Annual exports will probably increase; however, as previously discussed, a number of factors influence exports, and these factors are difficult to accurately predict.

TABLE 8-7. U.S. EXPORTS BETWEEN 1967 AND 1978

Year	Exports		Percent of Total Production
	10^3 megagrams	(10^3 tons)	
1967	276	304	4.6
1968	261	288	4.3
1969	294	324	4.6
1970	305	336	4.7
1971	396	437	6.1
1972	435	480	6.4
1973	386	425	5.6
1974	512	564	7.5
1975	480	529	7.4
1976	585	645	8.5
1977	689	759	9.4
1978	657	724	∿ 9

1967-1973. Reference 17.

1974-1978. Reference 2.

Imports have historically been of an insignificant quantity. There is no indication that this situation will change.

8.1.2.6 Historical And Future Trends In Prices. The prices of synthetic sodium carbonate, f.o.b. plant, have historically been, and presently are, somewhat higher than the f.o.b. plant prices for natural sodium carbonate. However, most natural sodium carbonate has to be shipped greater distances to its markets. These transportation costs for natural sodium carbonate generally offset the f.o.b. plant price advantage of natural sodium carbonate over synthetic sodium carbonate. Average f.o.b. plant prices for synthetic and natural sodium carbonate for the years 1967 through 1978 are presented in Table 8-8. Synthetic sodium carbonate is produced in two grades, Light Ash and Dense Ash. Dense Ash has always been priced slightly higher than Light Ash. The difference during those years that data were found, 1967 through 1972, was under one dollar per megagram. The price figures reported in Table 8-8 for the years 1967 through 1972 were calculated by multiplying the prices for Light Ash and Dense Ash by their respective fraction of total synthetic production and then adding the two products. The ratio of Light Ash to Dense Ash was approximately 2 to 3 for the years 1967 through 1972. Price data for Dense Ash from 1973 to the present were not found. However, since the price difference between Light Ash and Dense Ash was found to be small, the reported figures, which are for Light Ash only, should be sufficiently accurate for most calculations.

As indicated in Table 8-8, actual prices have increased rapidly in the recent past. Since 1970, prices for both synthetic and natural sodium carbonate have approximately tripled. This trend of increasing prices is expected to continue. Allied Chemical and Texasgulf raised prices by 5.5 dollars per megagram (5 dollars per ton) of bulk natural sodium carbonate as recently as April, 1979.[15]

In addition to actual prices, prices normalized to the 1978 value of money are reported in Table 8-8. These normalized prices were calculated from the actual prices by applying inflation index factors reported in the "GNP Implicit Price Deflator for 1978".[18] A graphical presentation of the normalized prices is presented in Figure 8-1. Two basic trends in

TABLE 8-8. SODIUM CARBONATE PRICES (1967-1978)

Year	Synthetic[a]				Natural[d]			
	$/megagram	$/ton	normalized $/megagram	normalized $/ton	$/megagram	$/ton	normalized $/megagram	normalized $/ton
1967	32.43	29.42	62.42	56.62	25.89	23.49	49.83	45.21
1968	32.46	29.45	59.79	54.25	22.72	20.61	41.85	37.96
1969	32.32	29.32	56.68	51.42	22.50	20.41	39.46	35.80
1970	33.96	30.81	56.53	51.29	23.18	21.03	38.59	35.01
1971	34.53	31.33	54.69	49.63	23.38	21.21	37.03	33.60
1972	38.13	34.59	57.99	52.61	24.56	22.28	37.35	33.89
1973	40.34	36.60	57.99	52.61	27.95	25.36	40.18	36.46
1974	53.06	48.14	69.56	63.11	37.33	33.87	48.94	44.40
1975	66.93	60.72	80.06	72.63	46.52	42.20	55.65	50.48
1976	79.29	71.93	90.16	81.79	54.78	49.70	62.29	56.51
1977	b		b		59.71	54.17	64.13	58.18
1978	110[c]	96	110	96	67[e]		67	61

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[a] 1967-1972 values were calculated as a weighted average of the prices for Dense Ash and Light Ash.
1973-1976 values were based on Light Ash only.
1967-1976 raw data for the calculations were obtained from Reference 19.

[b] Value was not obtained.

[c] During 1978 the bulk price increased to 110/megagram ($96/ton) from a previous price of $94/megagram ($85/ton)

[d] 1967-1974 Reference 13.
1974-1976 Reference 21.
1977 Reference 10.

[e] During 1978 the bulk price increased to $67/megagram ($61/ton) from a previous price of $61/megagram ($55/ton). Reference 20.

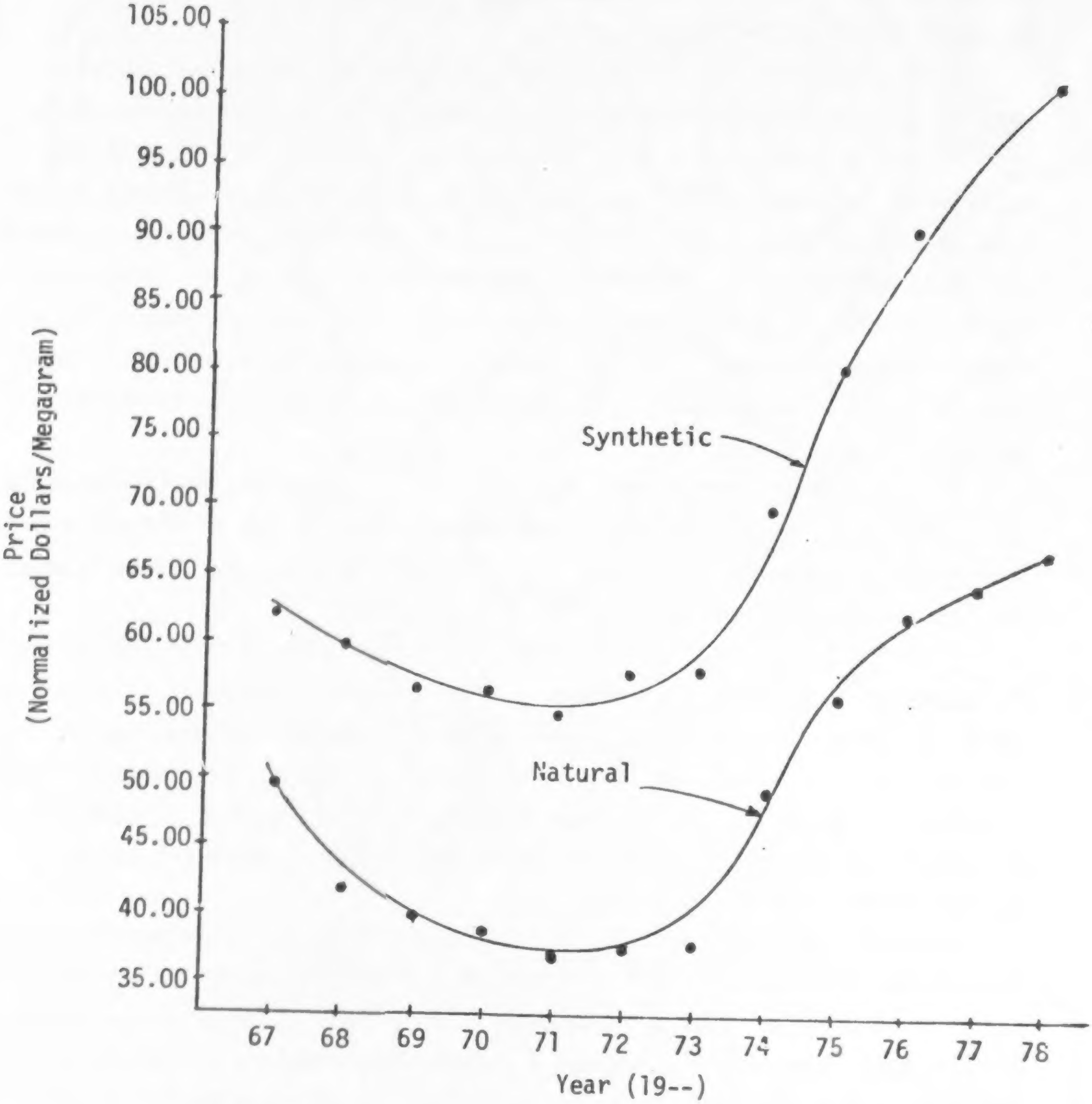


Figure 8-1. F.o.b. plant prices for natural and synthetic sodium carbonate normalized to a 1978 base.

normalized prices are indicated. These are the decrease in normalized prices through 1971, and the subsequent increase in normalized prices which became significant in 1973.

The decrease in normalized prices through 1971 can be attributed partially to competition between caustic soda and sodium carbonate (Normalized prices of caustic soda also decreased during this period), and some competition between natural and synthetic sodium carbonate. Energy prices were relatively stable during this period. In 1973 energy prices increased at a rate substantially higher than the rate of inflation. As discussed in Section 8.1.2.4, a significant portion of the total cost of production of sodium carbonate is energy cost. The rapid increase in energy costs since 1973 is believed to be the major contributor to the increase in normalized sodium carbonate prices.

In addition to energy, more raw materials, labor, and cooling water are used per ton of product in the Solvay process than in any of the natural processes. A comparison of the usage of these items in the Solvay process and the monohydrate process is given in Table 8-9.

If normalized price trends since the early 1970's are an indication of future trends, normalized prices will continue to increase. Figure 8-2 contains linear extrapolations over the next 5 years of natural sodium carbonate prices normalized to the 1978 value of money. Extrapolation based on price trends during the previous 5 years and the previous 3 years are presented. The extrapolations are based on a least squares fit to the average normalized price by year.

8.1.2.7 Utilization of Capacity. Yearly industry average utilization factors for producers of sodium carbonate may be derived by taking the ratio of production, listed in Table 8-4, to capacity, reported in Tables 8-5 and 8-6. Accurate utilization factors during those years of plant closings, plant startups, or plant expansions cannot be obtained by this method. Utilization factors were calculated for the years 1967, 1968, 1972, and 1974 for the synthetic industry. No trends were seen in these yearly utilization factors. The average value was 0.89. For the natural sodium carbonate industry, utilization factors were calculated for 1968, 1970,

TABLE 8.9. RAW MATERIAL, LABOR, COOLING WATER, AND ENERGY USAGES FOR PRODUCTION OF SODIUM CARBONATE BY THE SYNTHETIC AND THE MONOHYDRATE PROCESS

	Synthetic	Monohydrate
Raw Materials - Mg per Mg of product (ton per ton of product)	8 (8)	2.5 (2.5)
Labor - Manyear per Mg of product (Manyear per ton of product)	1.1×10^{-3} (1×10^{-3})	5.5×10^{-4} (5×10^{-4})
Cooling Water - m^3 per minute per Mg of product (gal. per minute per ton of product)	8×10^{-2} (20)	5×10^{-3} (<1)
Energy Requirements - Joules per Mg of product (BTU per ton of product)	 1.58×10^{10} (13.6×10^{6})	 7.3×10^{9} (6.3×10^{6})

Reference 22.

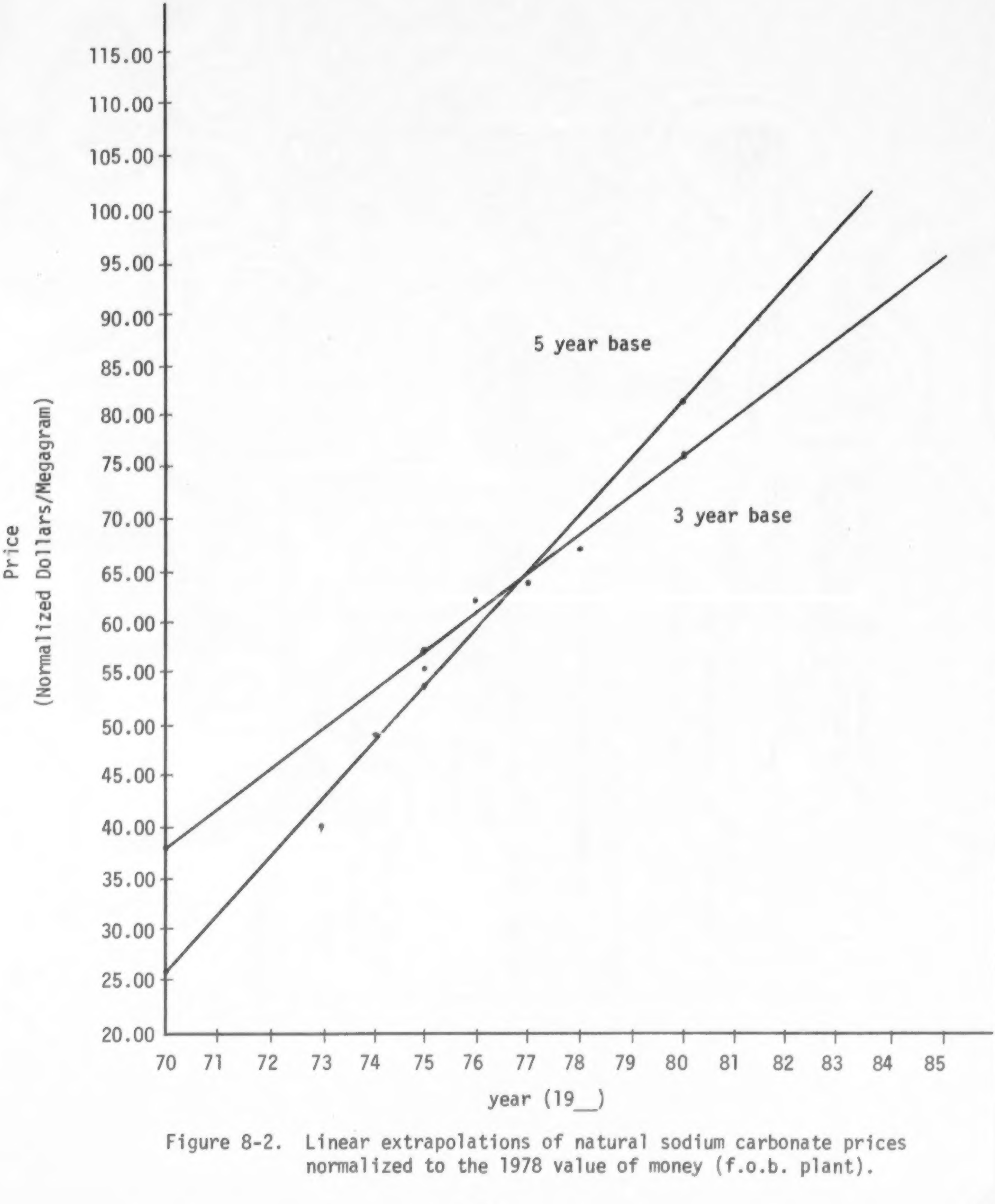


Figure 8-2. Linear extrapolations of natural sodium carbonate prices normalized to the 1978 value of money (f.o.b. plant).

1971, 1974, and 1975. No trends were seen in these yearly utilization factors. The average was 0.92.

The utilization factors caculated above are relatively high. It appears that the sodium carbonate industry has been producing at essentially a maximum rate since 1967, considering that downtime from equipment and manpower problems are included in the calculated utilization factors. There is no indication that this will change in the foreseeable future.

8.1.2.8 Replacement of Equipment. Most of the natural sodium carbonate plants are relatively young considering the expected service life of the processing equipment. The major pieces of processing equipment can be expected to have an indefinite service life (+30 years). Thus, replacement of worn out or depreciated equipment is not expected to be a significant cost over the next five years.

8.1.2.9 Future Construction Of New Plants And Additions To Existing Capacity. Construction of new natural sodium carbonate plants and the expansion of existing natural sodium carbonate plants will occur in the near future. Both Stauffer and FMC Corporation have expansions of approximately 0.27 million Mg/year (0.3 million TPY) planned for completion in early 1981.[15] Tenneco plans to complete construction on a new 0.91 million Mg/year (1.0 million TPY) plant in Wyoming by 1982.[20]

In addition to these additions to present capacity, construction of three new plants with production capacities of 454,000 Mg/yr (500,000 TPY) each could occur by 1985. This projection is based on the production projections made by the U.S. Bureau of Mines and on the assumption that the single remaining Solvay process plant will be shut down.

Additions to natural sodium carbonate capacity, subsequent to those additions mentioned above, will probably occur both by the startup of new plants and by the expansion of existing plants. New plants will probably be constructed near the ore deposits at Green River, Wyoming or Searles Lake, California. Other potential sites are Owens Lake, California, where there are deposits similar to those at Searles Lake, and areas in Utah and Colorado which have large deposits of nahcolite,[24] a sodium ore. However, if historical trends continue, most future activity will be near Green River, Wyoming. The consensus of opinions among plant engineers in this area is that any new facilities will employ either the monohydrate or an anhydrous process.[25] The anhydrous process involves the same unit operations as the monohydrate process, but the crystals from the crystallizers in the anhydrous process do not contain bound water. Crystals from the crystallizers in the monohydrate process contain bound water which must be removed in the product dryers. Operating conditions in the crystallizer are different in the anhydrous process to allow generation of these different crystals.

8.2 COST ANALYSIS OF REGULATORY CONTROL ALTERNATIVES

8.2.1 Introduction

An analysis of the costs of regulatory control alternatives for the sodium carbonate industry is presented in this section. Model sodium carbonate plants and regulatory alternatives on which the cost analysis is based are discussed in Chapter 6 and summarized in Tables 8-10, 8-11 and 8-12.

As shown in Table 8-10, six model plants are defined. Three of the plants have one processing train that produce 454,000 Mg/yr (500,000 TPY) sodium carbonate and three plants have two processing trains that produce a total of 907,000 Mg/yr (1,000,000 TPY). Each facility is assumed to operate at full capacity 7446 hours per year (85 percent capacity factor).

The characteristics of the stack emissions before their control are presented in Table 8-11 for the facilities in these model sodium carbonate plants. Control options for each of the facilities in the model plants are presented in Table 8-12. The percent reduction given in Table 8-12 is based on the uncontrolled particulate emission rates presented in Chapter 6 (Table 6-3) and controlled particulate emission rates presented in Chapter 7. The particulate emission rate for existing plants (see baseline alternatives in Table 8-12) is based on SIP requirements for the states of Wyoming and California, as discussed in Section 3.3. Emission rates for the other

TABLE 8-10. MODEL SODIUM CARBONATE PLANTS

Number	Plant size	Number of trains	Capacity, 10^6 Mg/yr (TPY)	Configuration	Process	Facilities in each train
1	Small	1	0.454 (0.5)	1	Monohydrate	Coal-fired calciner, rotary steam tube dryer
2	Medium	2	0.907 (1.0)	1	Monohydrate	Coal-fired calciner, rotary steam tube dryer
3	Small	1	0.454 (0.5)	2	Monohydrate	Coal-fired calciner, fluid bed steam tube dryer
4	Medium	2	0.907 (1.0)	2	Monohydrate	Coal-fired calciner, fluid bed steam tube dryer
5	Small	1	0.454 (0.5)	3	Direct carbonation	Rotary steam heated predryer, gas-fired bleacher, rotary steam tube dryer
6	Medium	2	0.907 (1.0)	3	Direct carbonation	Rotary steam heated predryer, gas-fired bleacher, rotary steam tube dryer

TABLE 8-11. EMISSION PARAMETERS FOR UNCONTROLLED MODEL SODIUM CARBONATE PLANTS

Facility	Plant Number[a]	Feed rate Mg/hr (tph)	Gas flow rate Actual m^3/min (acfm)	Gas flow rate Standard[b] Nm^3/min (scfm)	Particulate Concentration g/dNm^3 (gr/dscf)	Gas Temp. °C (°F)	Moisture Content Vol. %
Coal-fired Calciner	1 (2)	118 (130)	8,700 (307,000)	4,010 (142,000)	119 (52)	230 (450)	20
Rotary Steam Tube Dryer	1 (2)	64[c] (70)	1,600 (56,600)	1,040 (36,600)	52 (23)	88 (190)	40
Coal-fired Calciner	3 (4)	118 (130)	8,700 (307,000)	4,010 (142,000)	119 (52)	230 (450)	20
Fluid Bed Steam Tube Dryer	3 (4)	64[c] (70)	3,120 (110,200)	1,840 (64,900)	59 26	120 (248)	30
Predryer[d]	5 (6)	118[e] (130)	4,420 (156,000)	3,790 (134,000)	0.82 (0.36)	46 (115)	6
Bleacher	5 (6)	82 (90)	1,170 (41,210)	668 (23,600)	70 (30)	204 (400)	8
Rotary Steam Tube Dryer	5 (6)	64[c] (70)	1,370 (48,300)	1,040 (36,600)	52 (23)	88 (190)	40

[a] Plant numbers in parentheses are for medium size plants. These plants have 2 trains, each of which has the emission sources and parameters presented. Thus, to give total emission rates and gas flow rates for the medium size plants, multiply the table values by 2.

[b] Standard conditions are 20°C and 1.013×10^5 Pa (68°F and 14.7 psia).

[c] Dry product.

[d] The reported values are for both predryers in the train.

[e] Dry basis.

TABLE 8-12. CONTROL OPTIONS FOR MODEL SODIUM CARBONATE PLANTS

Case Number	Plant[a] Size	Alternative	Facilities	Type of Control[b]	% Reduction
1a	S	Alt. 1-Baseline	Coal fired calciner	C/ESP	99.92
			Rotary steam tube dryer	VS	99.18
1b	S	Alt.2	Coal-fired calciner	C/ESP	99.95
			Dissolver	None	None
			Rotary steam tube dryer	VS	99.87
2a	M	Alt. 1-Baseline	Coal fired calciner	C/ESP	99.92
			Rotary steam tube dryer	VS	99.18
2b	M	Alt. 2	Coal-fired calciner	C/ESP	99.95
			Rotary steam tube dryer	VS	99.87
3a	S	Alt. 1-Baseline	Coal-fired calciner	C/ESP	99.92
			Fluid bed steam tube dryer	C/VS	99.65
3b	S	Alt. 2	Coal-fired calciner	C/ESP	99.95
			Fluid bed steam tube dryer	C/VS	99.94

TABLE 8-12. CONTROL OPTIONS FOR MODEL SODIUM CARBONATE PLANTS (continued)

Case Number	Plant[a] Size	Alternative	Facilities	Type of Control[b]	% Reduction
4a	M	Alt. 1-Baseline	Coal fired calciner	C/ESP	99.92
			Fluid bed steam tube dryer	C/VS	99.65
4b	M	Alt. 2	Coal-fired calciner	C/ESP	99.95
			Fluid bed steam tube dryer	C/VS	99.94
5a	S	Alt. 1-Baseline	Predryer	VS	90.59
			Bleacher	C/ESP	99.81
			Rotary steam tube dryer	VS	99.74
5b	S	Alt. 2	Predryer	VS	97.30
			Bleacher	C/ESP	99.94
			Rotary steam tube dryer	VS	99.87
6a	M	Alt. 1-Baseline	Predryer	VS	90.59
			Bleacher	C/ESP	99.81
			Rotary steam tube dryer	VS	99.74
6b	M	Alt. 2	Predryer	VS	97.30
			Bleacher	C/ESP	99.94
			Rotary steam tube dryer	VS	99.87

[a] S = Small (one train); M = Medium (two trains)

[b] C = Cyclone; ESP = Electrostatic Precipitator; VS = Venturi Scrubber

control alternative in Table 8-12 are based on emission factors of 0.10 kg/Mg (0.20 lb/ton) of feed for calciners, 0.04 kg/Mg (0.08 lb/ton) dry product for rotary and fluid bed steam tube dryers, 0.04 kg/Mg (0.08 lb/ton) dry feed for predryers, and 0.02 kg/Mg (0.04 lb/ton) feed for bleachers.

Sources of data used in the cost analysis were vendor quotes, cost estimating manuals, and published reports. Vendor quotes were obtained for the major cost items (electrostatic precipitators, venturi scrubbers, and cyclones). Cost estimating manuals and published reports[26,27,28] were used to obtain costs for auxiliary equipment (such as fans, pumps, conveyors, and duct work), for installation costs, and for indirect costs. Engineering calculations, vendor data, and published reports were used to estimate direct operating costs and annualized costs. These data sources will be discussed in more detail in Sections 8.2.2.1 and 8.2.2.2. Assumptions used in calculating capital and annualized costs will also be discussed in these sections.

The factors used for installation costs and indirect costs and the values used for labor costs were generalized factors, and may be lower than actual costs that would be incurred in Wyoming because of harsh weather conditions and high labor rates. However, these factors would affect the costs for both regulatory alternatives, and thus would not affect the incremental costs for Alternative 2 over Alternative 1.

Cyclones were included as part of the emission control system for calciners, fluid bed steam tube dryers, and bleachers for this cost analysis. Cyclones are considered as part of the emission control system since they lower uncontrolled emissions and reduce the particulate load to the subsequent particulate removal device (ESP or venturi scrubber) and thus reduce its cost. Cyclones could also be considered as an integral part of the process used for economic recovery of product from particulate laden exit gas. In fact, a cyclone or low energy scrubber would most likely be used for product recovery even in the absence of air quality regulations. However, since cyclones of the same efficiency and same cost are used for both control alternatives, considering cyclones as emission control equipment does not affect the incremental costs for Alternative 2 over Alternative 1.

8.2.2 New Facilities

Costs for controlling the model plants listed in this section and discussed in Chapter 6 to the control levels indicated in Section 8.2.1 are discussed in this section for new facilities. As discussed in Section 8.2.1, two different model plant sizes are considered. The larger (two train) plant is representative of a new plant. The most recently built monohydrate process plant and a new plant planned for construction are of this size. The smaller (one train) plant is representative of an expansion to an existing plant. As discussed in Chapters 3 and 6, sodium carbonate plants are typically built and expanded by the construction of essentially independent processing trains. Costs for emission control for a two train plant are thus approximately double the costs of a one train plant. For this reason, control costs are presented in this section for each facility independently.

8.2.2.1 Capital Costs. Capital cost estimates for each control system were developed by determining basic equipment costs, and then applying cost component factors to the basic equipment costs to obtain total capital costs (including indirects). The capital costs represent the total investment required for purchase and installation of the basic control equipment and associated auxiliaries. Costs for research and development and costs for possible production losses during equipment installation and start up are not included. All costs are in mid-1979 dollars.

Specifications for the emission control systems are summarized in Table 8-13. These specifications, along with the emission parameters and required removal efficiencies presented earlier, were used to calculate control equipment costs for each facility for each control level. Vendor quotes were obtained for the principal cost items (cyclones,[29] electrostatic precipitators,[30,31,32] and venturi scrubbers.[33,34]) Costs for auxiliary equipment (ductwork, dust conveyors, fans and pumps) were obtained from cost estimating manuals.[26,27] These costs were scaled to mid-1979 dollars using the Chemical Engineering Fabricated Equipment Cost Index.

Component factors used to calculate installation costs and indirect costs are summarized in Table 8-14. The majority of these factors were obtained from reference 28. Costs for model studies and start up of an ESP were obtained from vendors for the calciner ESP.[30,31] These costs were scaled down for the bleacher ESP.

TABLE 8-13. SPECIFICATIONS FOR EMISSION CONTROL SYSTEMS

I. Cyclone/Electrostatic Precipitator for Calciner and Bleacher

  A. Ducting: 46m (150ft) length with elbows, diameter based on gas velocity of 15 m/s (3000 ft/min)

  B. Dust Removal:
    1. Cyclone: 9 inch diameter screw conveyor 23m (75 ft) long; two for calciner and one for bleacher
    2. ESP: Drag conveyor or scraper conveyor at bottom of ESP; 9 inch diameter screw conveyor to carry dust back into process, 46m (150 ft) for bleacher and 38m (125 ft) for calciner

  C. Pressure drop: 9 cm (3.5 in.) water for cyclone
    1 cm (0.5 in.) water for ESP
    5 cm (2.0 in.) water for ductwork
    5 cm (2.0 in.) water for calciner or bleacher
    20 cm (8.0 in.) water total

  D. Power requirement for ESP (total connected power)
    1. Bleacher: 80 kw for alt. 1
      90 kw for alt. 2
    2. Calciner: 480 kw for alt. 1
      550 kw for alt. 2

  E. Removal Efficiency
    1. Cyclone: 80%
    2. ESP: 99.62% Calciner alt. 1
      99.74% Calciner alt. 2
      99.05% Bleacher alt. 1
      99.67% Bleacher alt. 2

  F. Material of construction: carbon steel

II. Cyclone/Venturi Scrubber for Fluid Bed Steam Tube Dryer

  A. Ducting: 46 m (150 ft) length with 4 elbows, diameter based on gas velocity of 15 m/s (3000 ft/min)

  B. Dust Removal for cyclone: one nine inch diameter screw conveyor 15m (50ft) long

  C. Pressure drop: 9 cm (3.5 in.) water for cyclone
    19 cm (7.5 in.) water for venturi for alt. 1
    89 cm (35 in.) water for venturi for alt. 2
    5 cm (2 in.) water for ductwork
    5 cm (2 in.) water for dryer
    8 cm (3 in.) water for demister pad
    46 cm (18 in.) water total for alt. 1
    116 cm (45.5 in.) water total for alt. 2

D. Liquid to gas ratio: 1.6 ℓ/am^3 (12 gal/1000 acfm) inlet

E. Liquid head: $2.8\text{x}10^4$ Pa (4 psi) discharge pressure + 6m (20 ft) water + friction loss for 15 m (50 ft) pipe

F. Removal efficiency
  1. Cyclone: 80%
  2. Venturi scrubber: 98.25% for alt. 1
     99.72% for alt. 2

G. Material of construction: carbon steel

III. Venturi Scrubber for Rotary Steam Tube Dryer

A. Ducting: 38m (125 ft) length with 3 elbows, diameter based on gas velocity of 15 m/s (3000 ft/min)

B. Pressure drop: 15 cm (6 in.) water for alt. 1 (Wyo.)
38 cm (15 in.) water for alt. 1 (Calif.)
63 cm (25 in.) water for alt. 2
8 cm (3 in.) water for demister pad
5 cm (2 in.) water for ductwork
5 cm (2 in.) water for dryer
33 cm (13 in.) total for alt. 1 (Wyo.)
56 cm (22 in.) total for alt. 1 (Calif.)
81 cm (32 in.) total for alt. 2

C. Liquid to gas ratio: 1.6 ℓ/am^3 (12 gal/1000 acfm) inlet

D. Liquid head: same as cyclone/venturi-scrubber

E. Removal efficiency: 99.18% alt. 1 (Wyo.)
99.74% alt. 1 (Calif)
99.87% alt. 2

F. Material of construction: carbon steel

IV. Venturi Scrubber for Rotary Steam Heated Predryer

A. Ducting: 30m (100 ft) length with 2 elbows, diameter based on a gas velocity of 15 m/s (3000 ft/min)

B. Pressure drop: 15 cm (6 in.) water for scrubber for alt. 1
30 cm (12 in.) water for scrubber for alt. 2
5 cm (2 in.) water for demister
1 cm (.5 in.) water for ductwork
3 cm (1 in.) water for predryer
24 cm (10 in.) water total for alt. 1
39 cm (16 in.) water total for alt. 2

C. Liguid to gas ratio: 1.6 ℓ/am^3 (12 gal/1000 acfm) inlet

D. Liquid head: same as cyclone/venturi scrubber for fluid bed steam tube dryer

E. Removal Efficiency: 90.59% alt. 1
97.30% alt. 2

F. Material of Construction: carbon steel

TABLE 8-14. FACTORS USED FOR ESTIMATING INSTALLATION-COSTS AND INDIRECT COSTS AS A FUNCTION OF PURCHASED EQUIPMENT COST (Q)

	ESP	Venturi Scrubber
Instruments and Controls	a	0.10Q
Taxes	0.03Q	0.03Q
Freight	0.05Q	0.05Q
Purchased equipment cost (including auxiliaries)	Q	Q
Direct Installation Costs		
Foundations and supports	0.04Q[b]	0.06Q[b]
Erection and handling	0.50Q	0.40Q
Electrical	0.08Q	0.01Q
Piping	0.01Q	0.05Q
Insulation	0.02Q	0.03Q
Painting	0.02Q	0.01Q
Indirect Costs		
Engineering and supervision	0.20Q	0.10Q
Construction and field expense	0.20Q	0.10Q
Construction fee	0.10Q	0.10Q
Model study	0.10Q[c]	—
Start up	0.026Q[d]	0.01Q
Performance test	$6000	$6000
Contingencies	10% total direct and indirect	10% total direct and indirect
Working capital	25% total direct operating cost	25% total direct operating cost

[a] Included in purchased cost of ESP.

[b] Cyclone supports are calculated separately from reference 27.

[c] Model study cost based on $20,000 for calciner ESP.

[d] Start up cost based on $50,000 for calciner ESP.

Uninstalled costs for control equipment and required auxiliaries are presented in Table 8-15 for each facility. The components of these equipment costs are presented in Tables 8-16 through 8-27. Installation costs for each facility are also presented in these tables.

The ESP costs reported in these tables include insulation and all necessary instrumentation. Cost of the dust removal system is included with costs for the cyclone dust removal system. A drag bottom ESP is assumed, with a scraper conveyor at the bottom of the ESP to carry the collected dust away from the ESP to a screw conveyor, which carries the dust back into the process. Other auxiliaries for the ESP control system are a cyclone, ductwork, and a fan.

Venturi scrubber costs reported in these tables include the scrubber itself, an entrainment separator, and a mist eliminator. Other auxiliary equipment (ductwork, fan, and pump) is as noted.

Costs for continuous monitoring equipment which would be required under Alternative 2 are not reported in these tables. These costs are given in Appendix D, and would be the same for any of the Alternative 2 cases.

Total capital investment requirements (excluding continuous monitoring costs) for control of emissions are presented in Table 8-28 for each facility and in Table 8-29 for the entire plants. Capital costs which can be allocated to NSPS were calculated as the difference in cost between systems controlling emissions to the NSPS level (Alternative 2) and to the baseline level (Alternative 1).

As shown in Table 8-28, controlling particulate emissions to Alternative 2 levels would result in an increase in total capital investment ranging from 8 percent (for a bleacher) to 46 percent (for a rotary steam tube dryer) over costs that would be incurred in meeting Alternative 1. For a plant producing 454,000 Mg/yr (500,000 TPY) of sodium carbonate, total capital investment required for control of particulate emissions ranges from $1,943,000 to $4,857,000 (depending on process configuration) for Alternative 1 and from $2,148,000 to $5,520,000 for Alternative 2 (excluding continuous monitoring costs). Including continuous monitoring,costs for Alternative 2 would range from $2,183,000 to $5,548,000. Increase in capital investment required for meeting Alternative 2 over Alternative 1 ranges from about 12 to 14 percent.

TABLE 8-15. AIR POLLUTION CONTROL EQUIPMENT COSTS FOR SODIUM CARBONATE PLANTS

Equipment Type	Inlet Gas Flow Rate		Inlet Particulate Loading		Removal Efficiency	Equipment Cost Mid-1979$[a]
	m^3/min	acfm	g/dm^3	gr/dscf		
Cyclone/ESP	8700	307,000	119	52	99.92	1,718,000
Cyclone/ESP	8700	307,000	119	52	99.95	1,903,000
Cyclone/ESP	1170	41,210	70	30	99.81	506,000
Cyclone/ESP	1170	41,210	70	30	99.94	548,000
Venturi scrubber	1600	56,600	52	23	99.18	89,100
Venturi scrubber	1600	56,600	52	23	99.87	128,000
Venturi scrubber	1370	48,300	52	23	99.74	89,200
Venturi scrubber	1370	48,300	52	23	99.87	107,000
Cyclone/Venturi scrubber	3120	110,200	59	26	99.65	240,000
Cyclone/Venturi scrubber	3120	110,200	59	26	99.94	318,000
Venturi scrubber	4420	156,000	0.82	0.36	90.59	200,000
Venturi scrubber	4420	156,000	0.82	0.36	97.30	220,000

[a] Includes auxiliaries (fans, pumps, ductwork, conveyors), instrumentation, taxes and freight. Does not include installation or indirect costs.

TABLE 8-16. COMPONENT CAPITAL COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 1a,2a,3a,4a:

Coal-fired Calciner, 99.92%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
ESP	1,210,000	0.704
Cyclone	112,000	0.065
Ductwork	103,000	0.060
Scraper and screw conveyors	87,700	0.051
Fan, motor and starter, and damper	68,200	0.040
Taxes	51,500	0.03
Freight	85,900	0.05
TOTAL EQUIPMENT COST = Q	1,718,000	1.0
Direct Installation Costs		
Foundations and supports	84,700	0.049
Erection and handling	859,000	0.50
Electrical	137,000	0.08
Piping	17,200	0.01
Insulation	34,400	0.02
Painting	34,400	0.02
TOTAL	1,167,000	0.68
TOTAL DIRECT COSTS	2,885,000	1.68
Indirect Costs		
Engineering and supervision	344,000	0.20
Construction and field expense	344,000	0.20
Construction fee	172,000	0.10
Model study	20,000	0.012
Start up	50,000	0.029
Performance test	6,000	0.003
TOTAL INDIRECT COST	935,000	0.54
Contingency	382,000	0.22
TOTAL TURNKEY COST	4,202,000	2.45
Working Capital	99,300	0.058
GRAND TOTAL	4,301,000	2.50

TABLE 8-17. COMPONENT CAPITAL COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 1b, 2b, 3b, 4b:

Coal-fired Calciner, 99.95%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
ESP	1,380,000	0.725
Cyclone	112,000	0.059
Ductwork	103,000	0.054
Scraper and screw conveyors	87,700	0.046
Fan, motor and starter, and damper	68,200	0.036
Taxes	57,100	0.03
Freight	95,100	0.05
TOTAL EQUIPMENT COST = Q	1,903,000	1.0
Direct Installation Costs		
Foundations and supports	92,100	0.048
Erection and handling	951,000	0.50
Electrical	152,000	0.08
Piping	19,000	0.01
Insulation	38,100	0.02
Painting	38,100	0.02
TOTAL	1,291,000	0.68
TOTAL DIRECT COSTS	3,194,000	1.68
Indirect Costs		
Engineering and supervision	381,000	0.20
Construction and field expense	381,000	0.20
Construction fee	190,000	0.10
Model study	20,000	0.011
Start up	50,000	0.026
Performance test	6,000	0.003
TOTAL INDIRECT COST	1,028,000	0.54
Contingency	422,000	0.22
TOTAL TURNKEY COST	4,664,000	2.44
Working Capital	106,000	0.056
GRAND TOTAL	4,750,000	2.50

TABLE 8-18. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 1a, 2a:

Rotary Steam Tube Dryer, 99.18%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	30,000	0.34
Ductwork	17,200	0.19
Fan, motor and starter, and damper	21,300	0.24
Pump and motor	4,560	0.05
Instruments and Controls	8,910	0.10
Taxes	2,670	0.03
Freight	4,450	0.05
TOTAL EQUIPMENT COST = Q	89,100	1.0
Direct Installation Costs		
Foundations and supports	5,340	0.06
Erection and handling	38,600	0.40
Electrical	890	0.01
Piping	4,450	0.05
Insulation	2,670	0.03
Painting	890	0.01
TOTAL	49,900	0.56
TOTAL DIRECT COSTS	139,000	1.56
Indirect Costs		
Engineering and supervision	8,910	0.10
Construction and field expense	8,910	0.10
Construction fee	8,910	0.10
Start up	890	0.01
Performance test	6,000	0.067
TOTAL INDIRECT COST	33,600	0.38
Contingency	17,300	0.19
TOTAL TURNKEY COST	190,000	2.13
Working Capital	26,100	0.29
GRAND TOTAL	216,000	2.42

TABLE 8-19. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 1b, 2b:

Rotary Steam Tube Dryer, 99.87%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	30,000	0.23
Ductwork	17,200	0.13
Fan, motor and starter, and damper	53,200	0.42
Pump and motor	4,560	0.036
Instruments and Controls	12,800	0.10
Taxes	3,840	0.03
Freight	6,400	0.05
TOTAL EQUIPMENT COST = Q	128,000	1.0
Direct Installation Costs		
Foundations and supports	7,680	0.06
Erection and handling	51,200	0.40
Electrical	1,280	0.01
Piping	6,400	0.05
Insulation	3,840	0.03
Painting	1,280	0.01
TOTAL	71,600	0.56
TOTAL DIRECT COSTS	200,000	1.56
Indirect Costs		
Engineering and supervision	12,800	0.10
Construction and field expense	12,800	0.10
Construction fee	12,800	0.10
Start up	1,280	0.01
Performance test	6,000	0.047
TOTAL INDIRECT COST	45,700	0.36
Contingency	24,500	0.19
TOTAL TURNKEY COST	270,000	2.11
Working Capital	46,200	0.36
GRAND TOTAL	316,000	2.47

TABLE 8-20. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 5a, 6a:

Rotary Steam Tube Dryer, 99.74%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	30,000	0.34
Ductwork	15,000	0.17
Fan, motor and starter, and damper	23,900	0.27
Pump and motor	4,270	0.048
Instruments and Controls	8,920	0.10
Taxes	2,680	0.03
Freight	4,460	0.05
TOTAL EQUIPMENT COST = Q	89,200	1.0
Direct Installation Costs		
Foundations and supports	5,350	0.06
Erection and handling	35,700	0.40
Electrical	890	0.01
Piping	4,460	0.05
Insulation	2,680	0.03
Painting	890	0.01
TOTAL	50,000	0.56
TOTAL DIRECT COSTS	139,000	1.56
Indirect Costs		
Engineering and supervision	8,920	0.10
Construction and field expense	8,920	0.10
Construction fee	8,920	0.10
Start up	890	0.01
Performance test	6,000	0.067
TOTAL INDIRECT COST	33,700	0.38
Contingency	17,300	0.19
TOTAL TURNKEY COST	190,000	2.13
Working Capital	32,300	0.36
GRAND TOTAL	222,000	2.49

TABLE 8-21. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 5b, 6b

Rotary Steam Tube Dryer, 99.87%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	30,000	0.28
Ductwork	15,000	0.14
Fan, motor and starter, and damper	38,400	0.36
Pump and motor	4,270	0.04
Instruments and Controls	10,700	0.10
Taxes	3,210	0.03
Freight	5,340	0.05
TOTAL EQUIPMENT COST = Q	107,000	1.0
Direct Installation Costs		
Foundations and supports	6,410	0.06
Erection and handling	42,800	0.40
Electrical	1,070	0.01
Piping	5,340	0.05
Insulation	3,210	0.03
Painting	1,070	0.01
TOTAL	59,900	0.56
TOTAL DIRECT COSTS	167,000	1.56
Indirect Costs		
Engineering and supervision	10,700	0.10
Construction and field expense	10,700	0.10
Construction fee	10,700	0.10
Start up	1,070	0.01
Performance test	6,000	0.056
TOTAL INDIRECT COST	39,100	0.37
Contingency	20,600	0.19
TOTAL TURNKEY COST	226,000	2.10
Working Capital	41,200	0.39
GRAND TOTAL	268,000	2.50

TABLE 8-22. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 3a, 4a:

Fluid Bed Steam Tube Dryer, 99.65%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	50,000	0.21
Cyclone	56,000	0.23
Ductwork	30,500	0.13
Screw conveyors	3,800	0.016
Fan, motor and starter, and damper	50,600	0.21
Pump and motor	6,000	0.025
Instruments and Controls	24,000	0.10
Taxes	7,200	0.03
Freight	12,000	0.05
TOTAL EQUIPMENT COST = Q	240,000	1.0
Direct Installation Costs		
Foundations and supports	22,200	0.093
Erection and handling	96,000	0.40
Electrical	2,400	0.01
Piping	12,000	0.05
Insulation	7,200	0.03
Painting	2,400	0.01
TOTAL	142,000	0.59
TOTAL DIRECT COSTS	382,000	1.59
Indirect Costs		
Engineering and supervision	24,000	0.10
Construction and field expense	24,000	0.10
Construction fee	24,000	0.10
Start up	2,400	0.01
Performance test	6,000	0.025
TOTAL INDIRECT COST	80,400	0.34
Contingency	46,300	0.19
TOTAL TURNKEY COST	509,000	2.12
Working Capital	47,100	0.20
GRAND TOTAL	556,000	2.32

TABLE 8-23. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 3b, 4b:

Fluid Bed Steam Tube Dryer, 99.94%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	50,000	0.16
Cyclone	56,000	0.18
Ductwork	30,500	0.096
Screw conveyors	3,800	0.012
Fan, motor and starter, and damper	115,000	0.36
Pump and motor	6,000	0.019
Instruments and Controls	31,800	0.10
Taxes	9,550	0.03
Freight	15,900	0.05
TOTAL EQUIPMENT COST = Q	318,000	1.0
Direct Installation Costs		
Foundations and supports	26,900	0.085
Erection and handling	127,000	0.40
Electrical	3,180	0.01
Piping	15,900	0.05
Insulation	9,550	0.03
Painting	3,180	0.01
TOTAL	186,000	0.58
TOTAL DIRECT COSTS	504,000	1.58
Indirect Costs		
Engineering and supervision	31,800	0.10
Construction and field expense	31,800	0.10
Construction fee	31,800	0.10
Start up	3,180	0.01
Performance test	6,000	0.019
TOTAL INDIRECT COST	105,000	0.33
Contingency	60,900	0.19
TOTAL TURNKEY COST	670,000	2.11
Working Capital	99,700	0.31
GRAND TOTAL	770,000	2.42

TABLE 8-24. COMPONENT CAPITAL COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 5a,6a
Bleacher, 99.81%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
ESP	364,000	0.72
Cyclone	17,000	0.034
Ductwork	28,500	0.056
Scraper and screw conveyors	46,100	0.091
Fan, motor and starter, and damper	9,710	0.019
Taxes	15,200	0.03
Freight	25,300	0.05
TOTAL EQUIPMENT COST = Q	506,000	1.0
Direct Installation Costs		
Foundations and supports	22,900	0.045
Erection and handling	253,000	0.50
Electrical	40,400	0.08
Piping	5,060	0.01
Insulation	10,100	0.02
Painting	10,100	0.02
TOTAL	342,000	0.68
TOTAL DIRECT COSTS	848,000	1.68
Indirect Costs		
Engineering and supervision	101,000	0.20
Construction and field expense	101,000	0.20
Construction fee	50,600	0.10
Model study	6,000	0.012
Start up	15,000	0.029
Performance test	6,000	0.012
TOTAL INDIRECT COST	280,000	0.55
Contingency	113,000	0.22
TOTAL TURNKEY COST	1,241,000	2.45
Working Capital	18,900	0.037
GRAND TOTAL	1,260,000	2.49

TABLE 8-25. COMPONENT CAPITAL COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 5b,6b

Bleacher, 99.94%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
ESP	403,000	0.74
Cyclone	17,000	0.031
Ductwork	28,500	0.052
Scraper and screw conveyors	46,100	0.084
Fan, motor and starter, and damper	9,710	0.018
Taxes	16,400	0.03
Freight	27,000	0.05
TOTAL EQUIPMENT COST = Q	548,000	1.0
Direct Installation Costs		
Foundations and supports	24,600	0.045
Erection and handling	274,000	0.50
Electrical	43,800	0.08
Piping	5,500	0.01
Insulation	11,000	0.02
Painting	11,000	0.02
TOTAL	370,000	0.02
TOTAL DIRECT COSTS	918,000	1.68
Indirect Costs		
Engineering and supervision	110,000	0.20
Construction and field expense	110,000	0.20
Construction fee	54,800	0.10
Model study	6,000	0.012
Start up	15,000	0.029
Performance test	6,000	0.011
TOTAL INDIRECT COST	301,000	0.55
Contingency	122,000	0.22
TOTAL TURNKEY COST	1,341,000	2.45
Working Capital	19,900	0.036
GRAND TOTAL	1,360,900	2.48

TABLE 8-26. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 5a, 6a

Predryer, 90.59%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	63,000	0.32
Ductwork	38,800	0.19
Fan, motor and starter, and damper	54,500	0.27
Pump and motor	8,000	0.040
Instruments and Controls	20,000	0.10
Taxes	6,000	0.03
Freight	10,000	0,05
TOTAL EQUIPMENT COST = Q	200,000	1.00
Direct Installation Costs		
Foundations and supports	12,000	0.060
Erection and handling	80,200	0.40
Electrical	2,000	0.010
Piping	10,000	0.050
Insulation	6,000	0.030
Painting	2,000	0.010
TOTAL	112,000	0.56
TOTAL DIRECT COSTS	313,000	1.56
Indirect Costs		
Engineering and supervision	20,000	0.100
Construction and field expense	20,000	0.100
Construction fee	20,000	0.100
Start up	2,000	0.010
Performance test	6,000	0.03
TOTAL INDIRECT COST	68,100	0.34
Contingency	38,000	0.19
TOTAL TURNKEY COST	419,000	2.09
Working Capital	42,300	0.21
GRAND TOTAL	461,000	2.31

TABLE 8-27. COMPONENT CAPITAL COSTS FOR A VENTURI SCRUBBER FOR CASE 5b, 6b

Predryer, 97.30%

Component	Cost, Mid-1979 $	Factor
Purchased Equipment Cost		
Venturi scrubber, separator, and mist eliminator	63,000	0.29
Ductwork	38,800	0.18
Fan, motor and starter, and damper	70,200	0.32
Pump and motor	8,000	0.036
Instruments and Controls	22,000	0.100
Taxes	6,600	0.030
Freight	11,000	0.050
TOTAL EQUIPMENT COST = Q	220,000	1.00
Direct Installation Costs		
Foundations and supports	13,200	0.06
Erection and handling	87,800	0.40
Electrical	2,200	0.010
Piping	11,000	0.050
Insulation	6,590	0.030
Painting	2,200	0.010
TOTAL	123,000	0.56
TOTAL DIRECT COSTS	343,000	1.56
Indirect Costs		
Engineering and supervision	22,000	0.100
Construction and field expense	22,000	0.100
Construction fee	22,000	0.100
Start up	2,200	0.010
Performance test	6,000	0.011
TOTAL INDIRECT COST	74,100	0.34
Contingency	41,700	0.19
TOTAL TURNKEY COST	458,000	2.09
Working Capital	60,700	0.28
GRAND TOTAL	519,000	2.36

TABLE 8-28. TOTAL CAPITAL INVESTMENT FOR CONTROL OF PARTICULATE EMISSIONS FROM FACILITIES IN SODIUM CARBONATE PLANTS

Facility	Type of Control[a]	Particulate Emissions		Particulate Removal		Total Installed Capital Cost of Control[b]		INCREASE FOR ALT. 2 OVER ALT. 1[b]	
		ALT. 1 kg/Mg	ALT. 2 kg/Mg	ALT. 1	ALT. 2	ALT. 1	ALT. 2	$	%
Coal-fired Calciner	C/ESP	0.15	0.10	99.92	99.95	4,301,000	4,750,000	449,000	10
Rotary steam tube dryer - Wyo.	VS	0.25	0.04	99.18	99.87	216,000	316,000	100,000	46
Rotary steam tube dryer - Calif.	VS	0.08	0.04	99.74	99.87	222,000	268,000	46,000	21
Fluid bed steam tube dryer	C/VS	0.25	0.04	99.65	99.94	556,000	770,000	214,000	38
Bleacher	C/ESP	0.06	0.02	99.81	99.94	1,260,000	1,361,000	101,000	8
Predryer	VS	0.14	0.04	90.59	97.30	461,000	519,000	58,000	13

[a] C/ESP = Cyclone/ESP
C/VS = Cyclone/Venturi scrubber
VS = Venturi scrubber

[b] Total turnkey system costs and working capital, Mid-1979 cost basis. Costs for continuous monitoring not included.

TABLE 8-29. TOTAL CAPITAL INVESTMENT FOR CONTROL OF PARTICULATE EMISSIONS FROM MODEL SODIUM CARBONATE PLANTS[a]

Number	Plant size	Configuration	Process	Alt. 1	Alt. 2	Cost Increase for Alt. 2 over Alt. 1	
						$	%
1	Small	1	Monohydrate	$4,517,000	$5,094,000	577,000	12.8
2	Medium	1	Monohydrate	9,034,000	10,190,000	1,153,000	12.8
3	Small	2	Monohydrate	4,857,000	5,548,000	691,000	14.2
4	Medium	2	Monohydrate	9,714,000	11,100,000	1,381,000	14.2
5	Small	3	Direct carbonation	1,943,000	2,183,000	240,000	12.3
6	Medium	3	Direct carbonation	3,886,000	4,366,000	480,000	12.3

[a] Total turnkey system costs and working capital, mid-1979 cost basis. Costs for continuous monitoring are included.

8.2.2.2 Annualized Costs. Annualized costs represent the cost of operating and maintaining a pollution control system plus the cost of recovering the capital investment required for the system. The bases used in calculating annualized costs are summarized in Tables 8-30, 8-31, and 8-32. Utlity requirements were calculated based on the control system specifications given in Table 8-13. A 60 percent efficiency was assumed for pumps and fans.

A credit was assigned to the particulates removed by the control systems based on the values presented in Table 8-32. These values are based on a value of \$8.82/Mg (\$8/ton) for raw trona ore. This is the value assigned by the State of Wyoming Department of Revenue for tax purposes. Particulates recovered from the calciner are assumed to have the value of the raw trona ore plus the cost of energy for calcination. Particulates removed in the dryer scrubbers are recovered in an aqueous solution from which they must be recrystallized and re-dried. These particulates are assumed to have the value of an equivalent amount of calcined ore. Particulates recovered from the bleacher must undergo a comparable degree of processing (dissolution, crystallization, drying) and thus are assumed to have the same value as particulates removed in the dryer scrubbers. No product credit was given to particulates removed in the bleacher ESP since these are sometimes discarded rather than being returned to the process.

Components of the annualized costs for each control system are presented in Tables 8-33 through 8-44. Annualized costs for all the control systems are summarized in Table 8-45 for each facility, and in Table 8-46 for the entire plants. These tables do not include costs for continuous monitoring. The monitoring costs are reported in Appendix D.

As shown in Table 8-46, annualized costs for control of particulate emissions from a plant producing 454,000 Mg/yr (500,000 TPY) sodium carbonate range from a credit of \$2,061,000 to a cost of \$305,000 under Alternative 1, and from a credit of \$1,724,000 to a cost of \$455,000 under Alternative 2 (excluding monitoring costs). Including monitoring costs, annualized costs under Alternative 2 would range from a credit of \$1,712,000 to a cost of \$471,000. The increase in annualized costs for Alternative 2 over Alternative 1 is about 17 to 54 percent (including continuous monitoring).

TABLE 8-30. BASES FOR ANNUALIZED COSTS OF AIR POLLUTION CONTROL SYSTEMS

Item	ESP	Venturi Scrubber
Operating hours (hr/yr)	7446	7446
Direct Operating labor (hr/shift)	1	2
Maintenance labor (hr/shift)	0.5	1
Equipment life (years)	20	10
Interest rate (%)	12	12
Capital recovery factor (% of Total Turnkey Cost)	13.4	17.7

TABLE 8-31. ITEMS USED IN COMPUTING TOTAL ANNUALIZED COSTS

Item	Unit Value
Direct Operating Labor	\$8.80/hr
Supervision	15% of direct labor
Maintenance labor	\$9.70/hr
Maintenance materials[a]	100% of maintenance labor
Utilities	
Electricity[b]	\$0.048/kwh
Process water	\$0.074/m³ (\$0.28/1000 gal)
Overhead	80% of operating labor & supervision and maintenance labor
G&A, taxes, and insurance	4% of Total Turnkey Costs
Interest on working capital	12% of working capital

[a] For venturi scrubber, add \$4000 (for larger scrubber) or \$3000 (for smaller scrubber) for replacement parts.

[b] Multiply calculated value by 1.1 to account for line losses.

TABLE 8-32. RECOVERY CREDITS FOR PARTICULATES REMOVED IN POLLUTION CONTROL SYSTEMS

Facility/Removal Device	Credit for Recovered Product	
	$/Mg	$/ton
Coal-fired Calciner		
Cyclone	9.55	8.66
ESP	9.55	8.66
Bleacher		
Cyclone	16.30	14.80
ESP	None	None
Fluid bed steam tube dryer		
Cyclone	67	61
Venturi Scrubber	16.30	14.80
Rotary steam tube dryer		
Venturi Scrubber	16.30	14.80
Predryer		
Venturi scrubber	None	None

TABLE 8-33. COMPONENT ANNUALIZED COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 1a,2a,3a,4a
Coal-fired Calciner, 99.92%

Component	Cost, Mid-1979$ per year
Direct Costs	
Operating labor and supervision	9,420
Maintenance labor and materials	9,020
Utilities	379,000
Electricity	
TOTAL DIRECT COSTS	397,000
Overhead	11,100
Capital Charges	
G&A, taxes, and insurance	172,000
Capital recovery charges	576,000
Interest on working capital	11,900
TOTAL CAPITAL CHARGES AND OVERHEAD	771,000
TOTAL ANNUALIZED COSTS (without product recovery)	1,169,000
Credit for particulate recovery	
Cyclone	1,305,000
ESP	325,000
TOTAL CREDIT	1,630,000
NET ANNUALIZED COSTS (annualized costs-credit)*	- 461,000

*A negative value indicates a net credit

TABLE 8-34. COMPONENT ANNUALIZED COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 1b,2b,3b,4b:

Coal-fired Calciner, 99.95%

Component	Cost, Mid-1979$ per year
Direct Costs	
Operating labor and supervision	9,420
Maintenance labor and materials	9,020
Utilities	
Electricity	406,000
TOTAL DIRECT COSTS	424,000
Overhead	11,100
Capital Charges	
G&A, taxes, and insurance	186,000
Capital recovery charges	622,000
Interest on working capital	12,700
TOTAL CAPITAL CHARGES AND OVERHEAD	832,000
TOTAL ANNUALIZED COSTS (without product recovery)	1,256,000
Credit for particulate recovery	
Cyclone	1,305,000
ESP	325,000
TOTAL CREDIT	1,631,000
NET ANNUALIZED COSTS (annualized costs-credit)*	-374,000

*A negative value indicates a net credit

TABLE 8-35. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 1a,2a

Rotary Steam Tube Dryer, 99.18%

Component	Cost, Mid-1979 $ per year
Direct Costs	
Operating labor and supervision	18,900
Maintenance labor and materials	21,100
Utilities	
Electricity	58,200
Process water	6,620
TOTAL DIRECT COSTS	104,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	7,590
Capital recovery charges	33,600
Interest on working capital	3,130
TOTAL CAPITAL CHARGES AND OVERHEAD	66,600
TOTAL ANNUALIZED COSTS (without product recovery)	171,000
Credit for particulate recovery	
Venturi scrubber	
TOTAL CREDIT	234,000
NET ANNUALIZED COSTS (annualized costs-credit)*	-63,000

*A negative value indicates a net credit

TABLE 8-36. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 1b,2b:
Rotary Steam Tube Dryer, 99.87%

Component	Cost, Mid-1979 $ per year
Direct Costs	
Operating labor and supervision	18,900
Maintenance labor and materials	21,100
Utilities	
Electricity	138,000
Process water	6,260
TOTAL DIRECT COSTS	185,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	10,800
Capital recovery charges	47,800
Interest on working capital	5,540
TOTAL CAPITAL CHARGES AND OVERHEAD	66,000
TOTAL ANNUALIZED COSTS (without product recovery)	271,000
Credit for particulate recovery	
Venturi scrubber	
TOTAL CREDIT	236,000
NET ANNUALIZED COSTS (annualized costs-credit)*	35,500

*A negative value indicates a net credit

TABLE 8-37. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 5a,6a
Rotary Steam Tube Dryer, 99.74%

Component	Cost, Mid-1979 $ per year
Direct Costs	
Operating labor and supervision	18,900
Maintenance labor and materials	21,100
Utilities	
Electricity	83,100
Process water	6,260
TOTAL DIRECT COSTS	129,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	7,600
Capital recovery charges	33,600
Interest on working capital	3,880
TOTAL CAPITAL CHARGES AND OVERHEAD	67,400
TOTAL ANNUALIZED COSTS (without product recovery)	197,000
Credit for particulate recovery	
Venturi scrubber	
TOTAL CREDIT	235,000
NET ANNUALIZED COSTS (annualized costs-credit)*	-38,500

*A negative value indicates a net credit

TABLE 8-36. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 5b,6b

Rotary Steam Tube Dryer, 99.87%

Component	Cost, Mid-1979 $ per year
Direct Costs	
Operating labor and supervision	18,900
Maintenance labor and materials	21,100
Utilities	
Electricity	119,000
Process water	6,260
TOTAL DIRECT COSTS	165,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	9,060
Capital recovery charges	40,100
Interest on working capital	4,950
TOTAL CAPITAL CHARGES AND OVERHEAD	76,400
TOTAL ANNUALIZED COSTS (without product recovery)	241,000
Credit for particulate recovery	
Venturi scrubber	
TOTAL CREDIT	236,000
NET ANNUALIZED COSTS (annualized costs-credit)*	5,820

*A negative value indicates a net credit

TABLE 8-39. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 3a,4a
Fluid Bed Steam Tube Dryer, 99.65%

Component	Cost, Mid 1979$ per year
Direct Costs	
Operating labor and supervision	18,900
Maintenance labor and materials	22,100
Utilities	
Electricity	143,000
Process water	4,380
TOTAL DIRECT COSTS	189,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	20,400
Capital recovery charges	90,100
Interest on working capital	5,660
TOTAL CAPITAL CHARGES AND OVERHEAD	138,000
TOTAL ANNUALIZED COSTS (without product recovery)	327,000
Credit for particulate recovery	
Cyclone	1,820,000
Venturi scrubber	109,000
TOTAL CREDIT	1,930,000
NET ANNUALIZED COSTS (annualized costs-credit)*	-1,600,000

*A negative value indicates a net credit

TABLE 8-40. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 3b,4b
Fluid Bed Steam Tube Dryer, 99.94%

Component	Cost, Mid 1979$ per year
Direct Costs	
Operating labor and supervision	18,900
Maintenance labor and materials	22,100
Utilities	
Electricity	354,000
Process water	4,380
TOTAL DIRECT COSTS	399,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	26,800
Capital recovery charges	119,000
Interest on working capital	12,000
TOTAL CAPITAL CHARGES AND OVERHEAD	179,000
TOTAL ANNUALIZED COSTS (without product recovery)	578,000
Credit for particulate recovery	
Cyclone	1,820,000
Venturi scrubber	110,000
TOTAL CREDIT	1,930,000
NET ANNUALIZED COSTS (annualized costs-credit)*	-1,350,000

*A negative value indicates a net credit

TABLE 8-41. COMPONENT ANNUALIZED COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 5a, 6a

Bleacher - 99.81%

Component	Cost, Mid-1979$ per year
Direct Costs	
Operating labor and supervision	9,420
Maintenance labor and materials	9,020
Utilities	
Electricity	57,000
TOTAL DIRECT COSTS	75,400
Overhead	11,100
Capital Charges	
G&A, taxes, and insurance	49,600
Capital recovery charges	166,000
Interest on working capital	2,300
TOTAL CAPITAL CHARGES AND OVERHEAD	229,000
TOTAL ANNUALIZED COSTS (without product recovery)	305,000
Credit for particulate recovery	250,000
Cyclone	None
ESP	250,000
TOTAL CREDIT	
NET ANNUALIZED COSTS (annualized costs-credit)*	55,000

*A negative value indicates a net credit

TABLE 8-42. COMPONENT ANNUALIZED COSTS FOR AN ELECTROSTATIC PRECIPITATOR FOR CASE 5b, 6b

Bleacher - 99.94%

Component	Cost, Mid-1979$ per year
Direct Costs	
Operating labor and supervision	9,420
Maintenance labor and materials	9,020
Utilities	
Electricity	61,000
TOTAL DIRECT COSTS	79,400
Overhead	11,100
Capital Charges	
G&A, taxes, and insurance	53,600
Capital recovery charges	180,000
Interest on working capital	2,400
TOTAL CAPITAL CHARGES AND OVERHEAD	247,000
TOTAL ANNUALIZED COSTS (without product recovery)	326,000
Credit for particulate recovery	
Cyclone	250,000
ESP	None
TOTAL CREDIT	250,000
NET ANNUALIZED COSTS (annualized costs-credit)*	77,000

*A negative value indicates a net credit

TABLE 8-43. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 5a,6a

Predryer, 90.59%

Component	Cost, Mid 1979$ per year
Direct Costs	
Operating labor and supervision	18,800
Maintenance labor and materials	22,100
Utilities	
Electricity	125,000
Process water	3,340
TOTAL DIRECT COSTS	169,000
Overhead	22,300
Capital Charges	
G&A, taxes, and insurance	16,800
Capital recovery charges	74,100
Interest on working capital	5,080
TOTAL CAPITAL CHARGES AND OVERHEAD	118,000
TOTAL ANNUALIZED COSTS (without product recovery)	288,000
Credit for particulate recovery	
Venturi scrubber	None
TOTAL CREDIT	None
NET ANNUALIZED COSTS (annualized costs-credit)*	288,000

*A negative value indicates a net credit

TABLE 8-44. COMPONENT ANNUALIZED COSTS FOR A VENTURI SCRUBBER FOR CASE 5b,6b

Predryer, 97.30%

Component	Cost, Mid 1979$ per year
Direct Costs	
Operating labor and supervision	18,800
Maintenance labor and materials	22,100
Utilities	
Electricity	198,000
Process water	3,340
TOTAL DIRECT COSTS	243,000
Overhead	
Capital Charges	22,300
G&A, taxes, and insurance	18, 300
Capital recovery charges	81,100
Interest on working capital	7,280
TOTAL CAPITAL CHARGES AND OVERHEAD	129,000
TOTAL ANNUALIZED COSTS (without product recovery)	372,000
Credit for particulate recovery	
Venturi scrubber	None
TOTAL CREDIT	None
NET ANNUALIZED COSTS (annualized costs-credit)*	372,000

*A negative value indicates a net credit

TABLE 8-45. ANNUALIZED COSTS FOR CONTROL OF PARTICULATE EMISSIONS FROM FACILITIES IN SODIUM CARBONATE PLANTS[a]

Facility	Type of Control[b]	Particulate Removal %	Direct Costs $/yr	Capital Charges and Overhead $/yr	Total Annualized Cost $/yr	Net Annualized Cost[d] $/yr
Coal-fired calciner	C/ESP	99.92[c]	379,000	754,000	1,133,000	(461,000)
Coal-fired calciner	C/ESP	99.95	424,000	832,000	1.256,000	(374,000)
Rotary steam-tube dryer	VS	99.18[c]	104,000	66,600	171,000	(63,000)
Rotary steam-tube dryer	VS	99.87	185,000	86,400	271,000	35,500
Rotary steam-tube dryer	VS	99.74[c]	129,000	67,400	197,000	(38,500)
Rotary steam-tube dryer	VS	99.87	165,000	76,400	241,000	5820
Fluid bed steam tube dryer	C/VS	99.65[c]	189,000	138,000	327,000	(1,600,000)
Fluid bed steam tube dryer	C/VS	99.94	399,000	179,000	578,000	(1,350,000)
Bleacher	C/ESP	99.81[c]	75,400	229,000	305,000	55,000
Bleacher	C/ESP	99.94	79,400	247,000	326,000	77,000
Predryer	VS	90.59[c]	169,000	118,000	288,000	288,000
Predryer	VS	97.30	243,000	129,000	372,000	372,000

[a] All costs are in mid-1979$. Costs for continuous monitoring are not included.

[b] C/ESP = Cyclone/ESP; C/VS = Cyclone/Venturi scrubber; VS = Venturi scrubber

[c] Denotes baseline case.

[d] Including recovery credit. Values in parentheses are net credits.

TABLE 8-46. ANNUALIZED COSTS FOR CONTROL OF PARTICULATE EMISSIONS FROM MODEL SODIUM CARBONATE PLANTS[a]

Number	Plant size	Configuration	Process	Alt. 1	Alt. 2	Cost Increase from Alt. 1 over Alt. 2	
						$	%
1	Small	1	Monohydrate	$ (524,000)	$ (327,000)	197,000	38
2	Medium	1	Monohydrate	(1,050,000)	(653,000)	395,000	38
3	Small	2	Monohydrate	(2,061,000)	(1,712,000)	349,000	17
4	Medium	2	Monohydrate	(4,122,000)	(3,423,000)	699,000	17
5	Small	3	Direct Carbonation	305,000	471,000	166,000	54
6	Medium	3	Direct Carbonation	609,000	941,000	331,000	54

[a] Costs are net annualized costs (including recovery credits) in mid-1979 $ per year. Values in parentheses are net credits. Costs for continuous monitoring are included.

8.2.2.3 Cost Comparison. In this section, estimates of control system costs derived from different sources will be compared. Estimates of total turnkey system costs, however, are difficult to compare, because direct and indirect installation costs are quite variable, and it is frequently difficult to determine what components are included in a given estimate. It is thus difficult to compare costs of installed systems on a consistent basis. For these reasons, only costs for the major items of purchased equipment will be compared in this section.

Costs for electrostatic precipitators were obtained from vendors[30,31,32] from a cost estimating manual,[35] and from industry data. The costs from these sources are summarized in Table 8-47. As shown, cost estimates for the larger ESP obtained from different vendors are similar, but costs obtained from the estimating manual are significantly lower. The higher of the vendor estimates was used in the cost analysis. For the smaller ESP, the cost estimates show a much wider variation. The ESP in this case is fairly small, and design engineering costs can thus be excessive. The middle value of the three vendor quotes was used in the cost analysis.

Costs for venturi scrubbers were obtained from vendors[33,34] and from a cost estimating manual.[36] The costs from these sources are summarized in Table 8-48. Vendors indicated that the cost of the scrubber itself would be the same for the different control levels. Cost of the fan, however, would change because of the difference in scrubber pressure drop. As shown, the cost estimates from the three sources compare favorably. The higher of the vendor quotes was used in the cost analysis.

8.2.2.4 Cost Effectiveness. Two parameters that are often used in evaluating the cost of pollution control systems are cost effectiveness and marginal cost effectiveness. Cost effectiveness is defined as the total annualized cost of the pollution control system divided by the quantity of pollutant removed by the system. Marginal cost effectiveness is the incremental annualized cost per unit of pollutant removed above an arbitrary baseline. In this analysis, marginal cost effectiveness was calculated as follows:

TABLE 8-47. COMPARISON OF COST ESTIMATES OF ELECTROSTATIC PRECIPITATORS

Gas flow rate		Removal efficiency	F.O.B. cost estimates, 1979 $			
m^3/min	(acfm)	%	Vendor #1	Vendor #2	Vendor #3 or Industry Data	Cost Manual
8700	(307,000)	99.62	1,210,000[a]	1,200,000[a,b]	857,000[d]	590,000[c]
8700	(307,000)	99.74	1,380,000[a]	1,200,000[a,b]		599,000[c]
1170	(41,210)	99.05	100,000[a]	500,000[a,e]	366,000[a,f]	217,000[c]
1170	(41,210)	99.67	130,000[a]	500,000[a,e]	405,000[a,f]	230,000[c]

[a] Vendor quote, references 30, 31, 32.

[b] Includes cost for support steel not included in other estimates (~\$50,000)

[c] Reference 35, updated to mid-1979 $

[d] Industry data, updated to mid-1979 $

[e] Includes costs for support steel and freight not included in other estimates (~\$45,000)

[f] Includes cost for screw conveyor not included in other estimates (~\$2000)

TABLE 8-48. COMPARISON OF COST ESTIMATES OF VENTURI SCRUBBERS

Gas Flow Rate m^3/min (acfm)	FOB Cost Estimates, 1979$[a]		
	Vendor #1	Vendor #2	Cost Manual
1600 (56,600)	30,000[b]	26,131[b]	26,000[c]
3120 (110,200)	50,000[b]	45,493[b]	50,000[c]
4420 (156,000)	63,000[b]	—	59,000[c]

[a] Includes venturi scrubber, entrainment separator, and mist eliminator. Does not include pump or fan.

[b] Vendor quote, references 33, 34, 36.

[c] Reference 37 updated to 1979$.

$$MCE = \frac{C_2 - C_B}{P_2 - P_B}$$

where MCE = Marginal cost effectiveness

C_2 = Net annualized cost to remove a quantity of pollutant P_2

C_B = Net annualized cost to remove a quantity of pollutant P_B to meet a specified baseline level

Cost effectiveness and marginal cost effectiveness for the control options considered in this analysis are presented in Table 8-49.

The overall marginal cost effectiveness for a small monohydrate plant ranged from $1.41/kg of particulates removed ($1280/ton) to $2.50/kg ($2270/ton). The marginal cost effectiveness at a small direct carbonation plant was about $1.40/kg ($1270/ton).

As noted in Section 8.2.1, a cyclone was included as part of the control system for the calciner, bleacher, and fluid bed dryer. Inclusion of the cyclone in the control system costs has two major impacts on the cost analysis. First, because such a large mass of material is recovered in the cyclone at a low cost, inclusion of a recovery credit for material recovered in the cyclone in the total annualized costs for a control system offsets much of the direct operating costs and capital charges for the control system. In some cases, the resultant net annualized cost is actually a credit. Since the value of material recovered in the cyclone is generally greater than the annualized cost of the cyclone, inclusion of the cyclone recovery credit in the total costs of the emission control system leads to an offset of the cost of the other control devices (ESP or venturi scrubber) because of recovery credit from the cyclone. This can produce misleading results, especially since in many cases a cyclone would be an integral part of the process even in the absence of air quality regulations. For similar reasons, inclusion of the cyclone in the control system cost strongly impacts the cost effectiveness calculation. A large mass of particulates are removed in the cyclone at a low cost, while a relatively small mass are removed in the venturi scrubber or ESP at a higher cost. Thus, the combined cost effectiveness is somewhat misleading.

TABLE 8-49. COST EFFECTIVENESS OF CONTROL OF PARTICULATE EMISSIONS FROM SODIUM CARBONATE PLANTS

Facility	Type of Control[a]	Particulate Removal %	Cost Effectiveness[c]				Marginal Cost Effectiveness Relative to baseline	
			Excluding Recovery credits		Including Recovery credits[d]			
			$/kg	$/ton	$/kg	$/ton	$/kg	$/ton
Coal-fired calciner	C/ESP	99.92[b]	0.0068	6.21	(0.0027)	(2.45)	-[b]	-
Coal-fired calciner	C/ESP	99.95	0.0074	6.72	(0.0021)	(1.94)	2.35	2130
Rotary steam tube dryer	VS	99.18[b]	0.012	10.8	(0.044)	(3.98)	-[b]	-
Rotary steam rube dryer	VS	99.87	0.019	17.2	0.0027	2.44	1.04	925
Rotary steam tube dryer	VS	99.74[b]	0.014	12.4	(0.0027)	(2.42)	-[b]	-
Rotary steam tube dryer	VS	99.87	0.017	15.4	0.00063	0.573	2.50	2270
Fluid bed steam tube dryer	C/VS	99.65[b]	0.0097	8.81	(0.048)	(43.1)	-[b]	-
Fluid bed steam tube dryer	C/VS	99.94	0.017	15.6	(0.04)	(36.2)	2.56	2320
Bleacher	C/ESP	99.81[b]	0.016	14.5	0.0029	2.62	-[b]	-
Bleacher	C/ESP	99.94	0.018	15.9	0.0045	4.08	1.28	1157
Predryer	VS	90.59[b]	0.244	221	0.244	221	-[b]	-
Predryer	VS	97.30	0.297	270	0.297	270	0.923	837

[a] C/ESP = Cyclone/ESP
C/VS = Cyclone/Venturi scrubber
VS = Venturi scrubber

[b] denotes baseline case

[c] $\frac{\text{Total annualized cost}}{\text{Kg(ton) particulates removed}}$

[d] Values in parentheses indicate credits

[e] $\frac{\text{Total (or net) annualized cost - Total (or net) annualized cost for baseline}}{\text{kg(ton) particulates removed - kg(ton) particulates removed for baseline}}$

The effect of inclusion of the cyclone in the control system costs is demonstrated in Table 8-50, where cost effectiveness for the ESP without the cyclone is calculated. As shown, the cost effectiveness of the ESP is \$0.033/kg, compared to \$0.0074/kg for the cyclone/ESP (excluding recovery credits).

Neither of these impacts, however, affects the calculation of incremental costs or marginal cost effectiveness. Since the cost of the cyclone and the mass of the particulates removed in the cyclone are the same for both alternatives, the effects of the cyclone are subtracted out in the calculation of marginal cost effectiveness.

8.2.2.5 Base Cost of Facilities. The emission sources considered in this study do not comprise the entire sodium carbonate plant; therefore, costs for each facility in addition to costs for a complete sodium carbonate plant are presented.

The capital costs and the annualized operating costs for the uncontrolled facilities are presented in Table 8-51. Capital costs include purchased cost, installation cost, and indirect cost of the facilities and auxiliary equipment. Total capital investment for a new plant producing 907,000 Mg/yr (1 million TPY) of sodium carbonate is about \$280,000,000 including mine or well facilities.

Vendor[37] cost data were obtained for the purchased equipment cost of a rotary steam tube dryer and the rotary section of a coal-fired calciner. Vendor[38] cost was also obtained for the installed capital cost of the furnace for a coal-fired calciner. These vendor cost data, and information presented in Perry's Chemical Engineers Handbook[39], a U.S. Department of Commerce Publication[40], and in an article published in Control Technology News[41] were used to calculate the capital cost of the coal-fired calciner and the rotary steam tube dryer. The capital costs of the predryer and bleacher were estimated on the basis of information reported in references 38 and 39, and in Perry's Chemical Engineers Handbook.[42]

The capital costs of the fluid-bed steam tube dryer were estimated on the basis of vendor supplied cost for a gas-fired fluid bed dryer[43], the vendor cost data reported in reference 38 and information reported in reference 41.

TABLE 8-50. COST EFFECTIVENESS OF PARTICULATE REMOVAL FOR ELECTROSTATIC PRECIPITATOR COMPARED TO CYCLONE/ELECTROSTATIC PRECIPITATOR

	Cost Effectiveness	
	Cyclone/ESP	ESP
Excluding Recovery Credits		
$/kg	0.0074	0.033
$/ton	6.67	29.6
Including Recovery Credits		
$/kg	(0.0022)[a]	0.0231
$/ton	(1.99)[a]	20.9

[a] Net credit

TABLE 8-51. UNCONTROLLED FACILITY COSTS[a]

Facility	Feed Rate Mg/hr	Feed Rate TPH	Total Installed Capital Cost $	Direct Operating Cost $/yr	Capital Charges and overhead $/yr	Total Annual Operating Cost $/yr
Coal-fired Calciner	118	130	2,520,000	1,190,000	752,000	1,940,000
Rotary steam tube dryer	64[b]	70[b]	2,490,000	3,460,000	537,000	4,000,000
Fluid bed steam tube dryer	64[b]	70[b]	1,990,000	3,267,000	373,000	3,630,000
Predryer[c]	118	130	2,890,000	1,430,000	588,000	2,020,000
Bleacher	82	90	1,510,000	426,000	299,000	724,000

[a] All costs are in mid-1979$.

[b] Dry product.

[c] Data are for 2 predryers.

The capital costs of SIP controls are not included in the values reported in Table 8-51. These costs are presented in Section 8.2.2.1 (Alternative 1).

Annualized operating costs include the following:

- utilities
- maintenance
- operating labor and supervision
- the annualized capital cost.

The value of the feed material to each of the facilities is based on the operating cost of equipment "upstream" of the facilities. In many cases, this "upstream equipment" is another facility. Thus, to avoid including the operating cost of one facility in the operating cost of another facility, the cost of the feed material to each facility is not included in the annual operating cost.

Utility costs for the uncontrolled facilities are based on energy usage values presented in Chapter 3, and estimates of the electrical requirements to operate the facility. The cost factor assumed for each form of energy is presented in Table 8-52.

Maintenance costs were estimated on the basis of factors presented in Perry's Chemical Engineers Handbook[44] and information reported in reference 43. Maintenance costs include maintenance parts and labor.

Operating labor and supervision were estimated on the basis of factors reported in Perry's Chemical Engineers Handbook[38] and observations made while visiting sodium carbonate plants during source tests in 1979.

Overhead was assumed to be 80 percent of maintenance labor, operating labor, and supervision. Property tax, insurance, and administration are reported in a publication in Control Technology News[45] for pollution control equipment. These factors were assumed to apply across the board for all process equipment.

Annualized capital costs were computed using a compound interest rate of 12% and an equipment service life of 30 years.

Increased costs for pollution control equipment for meeting Alternative 2 over Alternative 1 represent about 4 to 20 percent of the total installed capital cost and about 3 to 7 percent of the total annualized cost of the individual uncontrolled facilities. The increased capital costs

TABLE 8-52. ENERGY COSTS[a]

Item	Unit Cost	
	Metric Units	English Units
Electricity	$.048/kwh	
Natural Gas	$.00213/10^6 J	($2.25/10^6 Btu)
Steam	$12.57/10^3 kg.	($5.70/10^3 lb.)
Coal	$.000446/10^6 J	($.47/10^6 Btu)

[a] Cost data are in terms of the mid-1979 value of money.

for pollution control represent less than 0.5 percent of the capital cost of a new sodium carbonate plant producing 907,000 Mg/yr (1 million TPY).

8.2.3 Modified/Reconstructed Facilities

As noted in Chapter 5, few modifications or reconstructions are anticipated for the sodium carbonate industry. Thus, the costs of control systems for modified/reconstructed facilities will have a minimal impact on the sodium carbonate industry.

However, if a modification or reconstruction were to occur, the cost for installing a control system in an existing plant that has been modified or reconstructed is generally greater than the cost of installing the control system in a new facility with the same exhaust gas parameters because special design modifications are often required.

Configuration of equipment in the existing plant governs the location of the control system. Depending on process or stack location, long ducting runs from ground level to the control device and to the stack may be required. The requirement for additional ducting can vary considerably, depending on plant configuration.

If space within the plant is tight, it may be necessary to install the control equipment on the roof of a process building, thus requiring the addition of structural steel support. Roof top installation would increase costs for installation of the control system.

Other cost components that may be increased because of space restrictions and plant configuration are contractor's fees and engineering fees. These fees vary from place to place and job to job depending on the difficulty of the job, the risks involved, and current economic conditions.

Estimating this additional installation cost or retrofit penalty is difficult because of these plant-specific factors and additional engineering requirements. However, the incremental costs to meet NSPS over the costs for retrofitting to meet state standards would be similar to the incremental costs for new plants, as presented in Section 8.2.2.

8.3 OTHER COST CONSIDERATIONS

8.3.1 Costs Imposed by Water Pollution and Solid Waste Disposal Regulations

Costs of compliance with water pollution and solid waste disposal regulations do not currently have a strong impact on sodium carbonate plants. Water and solid wastes in sodium carbonate plants are generally discharged to tailings ponds, from which waste water evaporates. No waste water is discharged into surface waters, and ground water in the area of the sodium carbonate plants is of very poor quality.

8.3.2 Costs Associated with MSHA Compliance

Sodium carbonate plants are under the jurisdiction of the Mine Safety and Health Administration (MSHA) and not the Occupational Safety and Health Administration (OSHA). MSHA regulations require training and education in safety and health and also deal with areas such as hazard abatement, nuisance dust, and noise. The sodium carbonate industry has no special problems requiring special MSHA regulations.

8.3.3 Compliance Testing (Air) Requirements

Compliance testing requirements for sodium carbonate plants would not be excessive. For a single processing train, 2 or 3 test sites would be required. Standard EPA test methods for particulates (such as Method 5) would be used. Lengthy test runs would not be required.

8.3.4 Regulatory Agency Manpower Requirements

Future sodium carbonate plants are expected to be located in California and Wyoming. Four plants are currently located in Wyoming, (with an additional new plant planned) and two in California. Compliance tests that would be required for sodium carbonate plants would be relatively simple. Thus, regulatory agency manpower requirements should not be excessive.

8.4 ECONOMIC IMPACT ASSESSMENT

8.4.1 Introduction and Summary

8.4.1.1 Introduction. This section assesses the economic impact of the alternative regulatory options on the Sodium Carbonate (soda ash) industry. Economic profile information on the industry presented in Section 8.1 is a principal input to this assessment. The impact on individual new sources will be assessed by using model plants that represent a new source (two trains) or an expansion of an existing plant (one train). Various financial analysis techniques are applied to the model plants to determine potential impacts on affordability and capital availability. These findings are assessed, based on the industry profile, to determine the industry-wide impacts that will be presented in Section 8.5.

As noted in previous chapters the facilities of interest are the calcining, bleaching, and drying operations of natural soda ash production. There is currently only one remaining plant that uses a synthetic production process and no new synthetic production plants are projected to be built. Therefore, controls for a synthetic plant are not within the scope of this study. The model plants use one of two primary production processes, either the monohydrate process or the direct carbonation process. Within the monohydrate process there is an option to use a rotary steam tube dryer or a fluid bed steam tube dryer. Hence, there are three model plant processes; monohydrate (rotary dryer), monohydrate (fluid bed dryer), and direct carbonation. Each process has two plant sizes so there are a total of six model plants. The monohydrate process is employed in producing soda ash from trona ore, and the direct carbonation process is employed in producing soda ash from brine.

8.4.1.2 Summary. A return on assets (ROA) analysis for the model plants demonstrates that the addition of the most stringent regulatory option is unlikely to have a significant profitability impact on the ROA for a soda ash plant.

The soda ash industry exhibits inelastic demand. Therefore it is likely that the cost of control will be passed-through to customers. Such a complete pass-through to customers will raise the price of soda ash by 1 percent for the model plant with the highest control costs. In the unlikely situation that the control cost must be absorbed by the producers, the present profit margins are such that the profit reduction is unlikely to have a major impact on ROA.

The cost of control will add at most .5 percent to the total initial investment required for a new monohydrate or direct carbonation model plant. The additional .5 percent will not restrict capital availability for the new plant.

The cost of control will add at most 7 percent to the total investment for the facilities of interest, exclusive of other facilities, required for an expansion of an existing monohydrate or direct carbonation plant. The additional 7 percent will not restrict capital availability for a model plant expansion.

Overall, the cost of control is unlikely to have a significant economic impact on the new plant or an expansion to an existing plant.

8.4.2 Ownership, Location, and Concentration Characteristics.

Five large publicly held corporations each with from three to six business segments own the eight soda ash plants in the United States. The various business segments may or may not be related to soda ash, and soda ash may be only one of several chemicals within a business segment. Some of these corporations are significant users of the soda ash they produce. The contribution to sales from soda ash ranges from approximately 1 percent to 7 percent of total sales in these corporations.

With the exception of the synthetic plant in New York the remaining plants are located in Wyoming and California.

8.4.3 Supply

In general terms the supply and demand relationship in the soda ash industry is stable. Production has grown at an average historical rate of 2 percent per year from 1967 to 1977. Production is projected to continue growing by 2-3 percent per year through 1985.[47]

In recent years there has been a sharp changeover from the production of synthetic to natural soda ash. Most of the former synthetic capacity is now closed and there has been a major expansion of natural capacity. In spite of the relatively short time involved and the magnitude of the changes in capacity, the expansion of capacity to produce natural soda ash has progressed in an orderly manner and has not caused disruptions in the market. The expansion of natural production has effectively offset the loss of synthetic production and met normal growth in demand, but at the same time has not resulted in excessive expansion of capacity leading to an over supply situation. This is evidenced by a 92 percent industry capacity utilization rate, and rising prices, which also suggest that new capacity will be required to meet growth projections.

Figure 8-3 illustrates this stability. The bottom two sections of the graph illustrate the extent of the change from the snythetic production process to the natural production process that has occurred over an eleven year span. As noted in Section 8.1 soda ash produced by the synthetic process has declined from 73.7 percent of total soda ash production in 1967 to 15.7 percent in 1978. At the same time, the production of soda ash from the natural process has increased in inverse proportion.

The top section of the graph illustrates that while the underlying changes in the production process were taking place, the growth in the total production of soda ash continued its historical pattern and was not significantly disrupted.

8.4.3.1 Substitutes. Substitutes can influence the economics of a given product by presenting an alternative source of supply to meet demand. The possibility of substitution is one of a number of market factors that act to check the price increases of a given product.

Caustic soda has historically been the only major substitute for soda ash. Caustic soda and soda ash share some common markets which represent roughly 40 percent of soda ash's end uses, primarily the chemicals market and the pulp and paper market. As noted in Section 8.1.2 from a former price advantage in favor of caustic soda, the prices of caustic soda have recently risen so now neither caustic soda nor soda ash has a distinct price advantage. Therefore, caustic soda is not currently as competitive as a substitute for soda ash as in past years.

8.4.4 Demand.

The industry exhibits inelastic demand over an appreciable price range. The weighted average price (both synthetic and natural) has risen by 139 percent over the past 11 years.[48] There is no evidence of a significant buildup of inventory in this industry nor is there a significant import market. Therefore production can be considered equivalent to demand in this case.

Figure 8-4 illustrates the inelastic demand for soda ash which is caused by several factors. First, the only significant substitute

Figure 8-3. STABILITY OF TOTAL PRODUCTION OF SODA ASH

1967 = 100

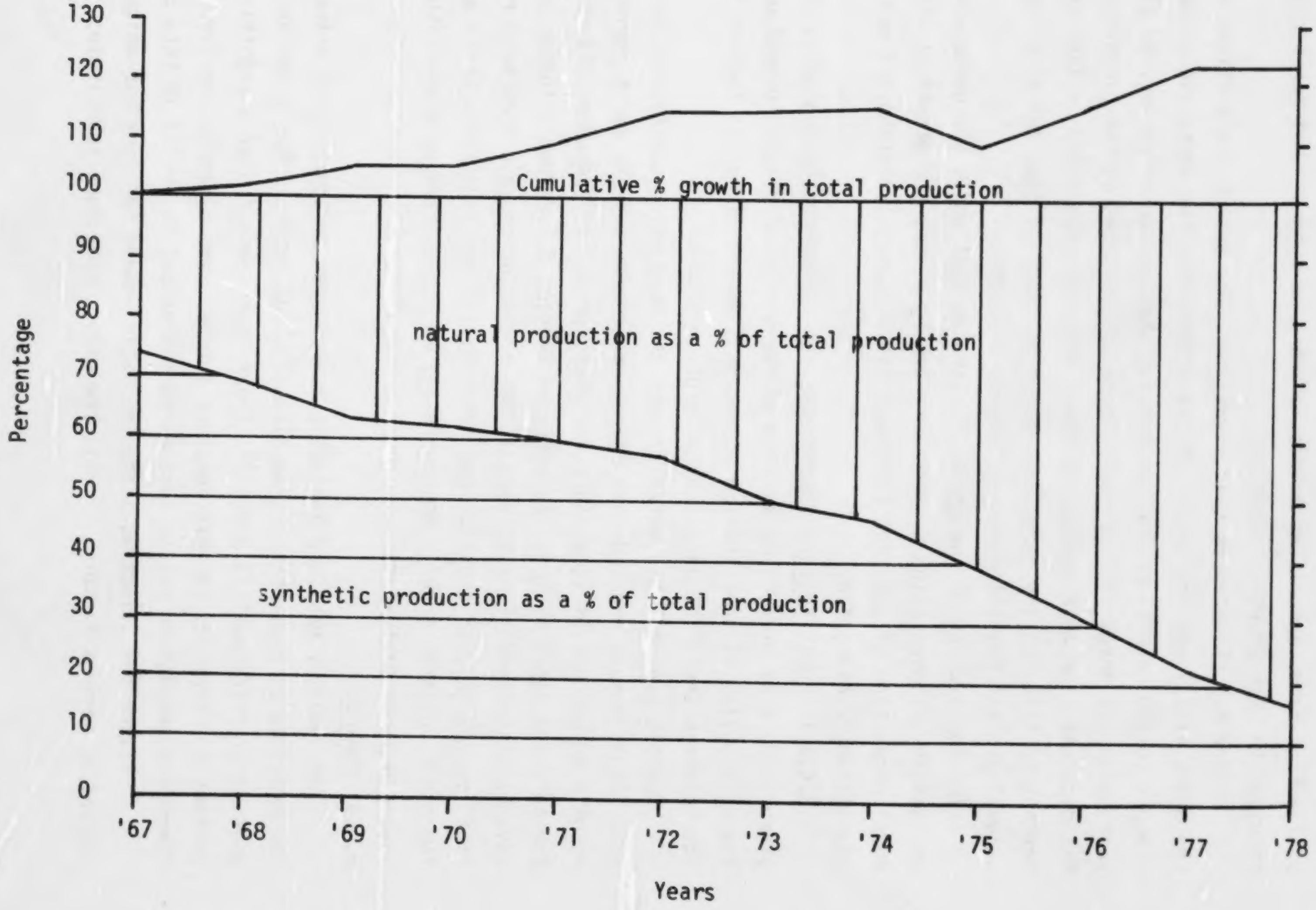
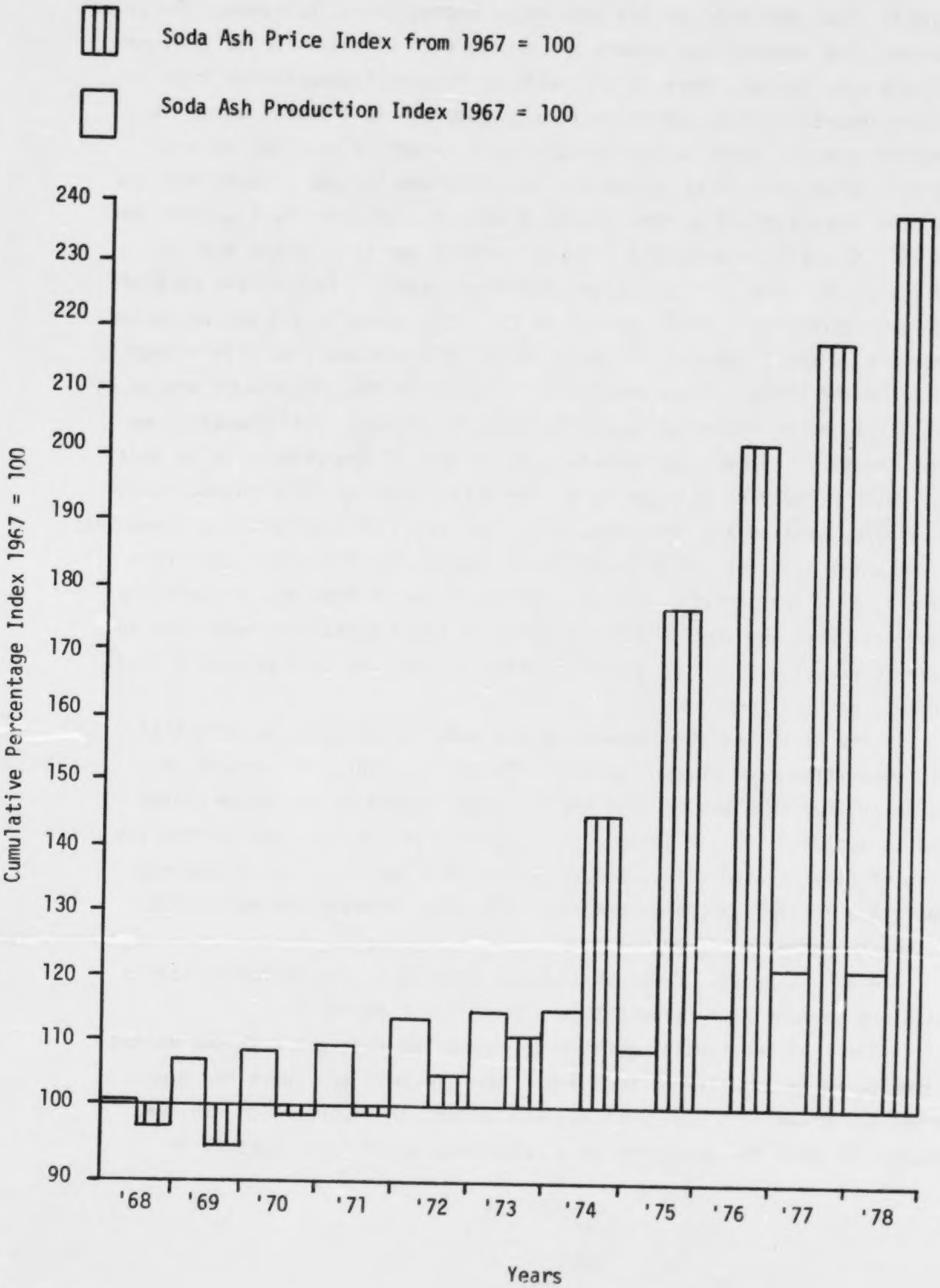


Figure 8-4. RELATIONSHIP BETWEEN PRICE AND PRODUCTION



(caustic soda) for soda ash has been experiencing price increases. The price increases for caustic soda reduce the pressure to hold down price increases for soda ash. Second, there is virtually no potential competition from foreign imports of soda ash since foreign soda ash is produced using the synthetic process which is considerably more expensive than the natural process. Third, the total demand for the end products that contain soda ash has been characterized by slow stable growth of approximately 2 percent per year.[47] As noted in Section 8.1.1 the relative position of the end use industries for soda ash has historically been stable. Fourth, the cost of soda ash represents a small portion of the total price of its end products. Therefore, a small increase in the price of soda ash would require a substantially lesser offsetting percent price increase in the end product and would have little or no impact on demand for the end product. For example, the glass industry consumes approximately 50 percent of the production of soda ash. Within the various segments of the glass industry (flat glass, glass containers, pressed & blown glass, etc.) the value of soda ash as a percentage of the total value of the end product is highest for the glass containers segment, 17.81 percent.[49] Therefore if the price of soda ash increases by 1 percent, then the amount that the price of glass containers must rise in order to offset a 1 percent price increase in soda ash is 1 percent x 17.81 percent, or .1781 percent.

In the glass industry segment of the soda ash markets the potential for competition from plastic exists. Plastic has made some inroads in the demand for soda ash but two factors both related to petroleum prices tend to support soda ash demand. As petroleum prices continue to rise the price of plastic also rises, and,as petroleum prices rise the demand for fiberglass insulation (which contains soda ash) increases as homeowners attempt to conserve energy.

8.4.4.1 Exports. Previous sections have noted the following points which are germane with respect to a discussion of exports.

There is substantial world-wide demand for soda ash with the United States being an exporter of soda ash. Over the past ten years the export market has grown from approximately 4.5 percent to 9 percent of U.S. production.[50] With the exception of a relatively small trona deposit in

Africa, the rest of the world produces soda ash using the Solvay process. The Solvay or synthetic process involves large amounts of energy and hence high energy costs and poses a considerable water pollution problem. The energy costs and/or the water pollution problem present the possibility that foreign synthetic production plants may close prematurely or older plants may not be replaced. Therefore the most likely replacement source of supply would be the U.S. with the associated economic benefits to the U.S. of increased export demand for soda ash, and an increased number of new sources. However, foreign closures do not appear imminent during the next five years.

8.4.5 Methodology

This section describes the methodology used to measure the economic impact of the cost of control on the soda ash industry. The principal economic impact which is assessed is the effect of incremental costs of control on the profitability of new grassroots plants and expansions of existing plants.

In the analysis, each new model soda ash plant is evaluated as if it stands alone, i.e., the firm is not associated with any other business activity nor is it associated with any larger parent company. This assumption has the effect of isolating the control cost from any assistance from other business activities or firms.

Since both the California and Wyoming state implementation plans (SIP) contain particulate emission control standards, any new plant would have to meet SIP standards even in the absence of an NSPS. Therefore, incremental control costs are the control costs over and above those baseline costs required to meet the SIP standards.

Economic impact is evaluated on a model plant of 1,000,000 tons per year capacity whose description is based on representative production and financial characteristics of a new or expanded soda ash plant. Results can readily be extrapolated to smaller and larger plants because capacity is attained by employing several production "trains", i.e. a 1,000,000 ton plant employs two 500,000 TPY trains.

The primary analytical technique employed in determining the impact of control costs on the affordability of a soda ash plant is return on assets (ROA) which compares net profit to the size of the asset base which is required to generate that profit. For example, a $10 profit earned on $100 of assets equals 1:10, or a 10 percent ROA.

Projecting the actual level of ROA without controls is not a major objective of this analysis. The issue of concern for this analysis is whether or not the change that occurs in ROA is such that a capital investment which would otherwise be accepted will now be rejected as a result of the addition of control costs. The actual level of ROA will vary from case to case and will be influenced by a number of factors such as the age of the assets. In this analysis, the actual level of ROA without control, is substantially below a level that might be termed "normal" for the industry for several reasons. The 85 percent capacity utilization rate used to estimate control costs in Section 8.2 and therefore also used in the model plant economic analysis is conservative. As mentioned in Section 8.1 the historic capacity utilization rate for the natural soda ash industry has been 92 percent. Using an 85 percent capacity utilization rate acts to reduce profit and lower ROA. The initial capital investment in a soda ash facility typically includes mine capacity for future expansion. This causes the ROA to be low in the early years of plant operation prior to such expansion. As capacity is expanded, a significant portion of the investment cost associated with expansion has been made previously at the time of the initial investment so that to gain additional units of capacity requires a proportionately smaller unit investment cost, which raises ROA. The 50 percent tax rate assumed in this analysis is higher than typical for the soda ash industry for several reasons. The 14 percent depletion allowance for trona is a significant contributor to a lower effective tax rate. Data on effective tax rates on trona are not separately available, but are combined in divisional product information. However, all indications suggest that these rates may be between 25 and 40 percent. Also, the 10 percent investment tax credit available on the plant facilities has not been included in this analysis which would further reduce effective tax rates. These conservative assumptions result in significantly understating the probable net profits in this industry. The purpose of this analysis is to determine the difference in ROA due to control investments. The conclusions relative to the impact of controls on the profitability of this industry are not affected by the conservative baseline assumptions.

The procedure employed is first to calculate the baseline ROA that would be earned without controls. Next, the most costly controls are added and the ROA is recalculated. The difference between the above two calculations represents the impact of the most costly controls on profitability as measured by ROA.

8.4.6 Profitability Analysis-Return on Assets

Table 8-53 shows the return on assets (ROA) analysis for a new 1,000,000 TPY plant without controls, a new plant with controls, and the difference in ROA between the two. All cost figures are in mid-1979 dollars.

In addition to the controls that are the subject of this project, new sources in the soda ash industry will also be regulated by the controls required for non-metallic mineral processing plants. The non-metallic mineral controls have not been finalized at this time. However, as they apply to the soda ash industry, the non-metallic mineral controls are expected to involve costs of approximately .1 percent of the sales price per ton of soda ash.

The numerator in the ROA analysis is net earnings after tax, taken as 8 percent of revenue. This is based on the historical pre-tax profit in the industry. For the five companies in the soda ash industry the average after tax profit on revenue for the years 1978, 1977, and 1976 for the business segment that includes soda ash was 8.4 percent.[46] This assumes taxes and interest represent a combined total rate of 50 percent. The 8.4 percent average margin has been rounded to 8.0 percent to be conservative and to adjust for the controls for non-metallic minerals. The price of dense soda ash sold in bulk form is \$66 per ton.[51,52]. As discussed in Section 8.1, annual production is 85 percent of 1,000,000 tons of capacity, or 850,000 tons per year. Therefore, the numerator is \$66/ton x 850,000 tons/year x 8 percent = \$4,488,000.

The denominator is the asset base. \$280,000,000 represents an approximation of the total assets required for a new facility including associated mine or well facilities with 1,000,000 tons capacity.[53, 54, 55, 56] Each year of the project life the assets would be depreciated and would result in a progressively smaller asset base supporting an essentially constant amount of total income. This action would cause a low ROA during the early years of the project and a high ROA during the late years. If straight line depreciation with no residual value is assumed this effect can be considered by multiplying the original committed assets by 1/2.

TABLE 8-53. CHANGE IN RETURN ON ASSETS FOR A 1,000,000 TPY PLANT ASSUMING NO COST PASS-THROUGH
($000's)

$$\text{ROA Without Control} = \frac{\text{Net Earnings After Tax}}{\text{Average Total Assets}}$$

$$= \frac{4{,}488}{140{,}000}$$

$$= 3.2\%$$

$$\text{ROA With Control} = \frac{(\text{Net Earnings After Tax}) - (\text{Control Cost After Tax})}{(\text{Avg. Total Assets}) + (\text{Avg. Control Investment})}$$

$$= \frac{4{,}488 - 338}{140{,}000 + 663}$$

$$= \frac{4{,}150}{140{,}663}$$

$$= 3.0\%$$

$$\text{Change In ROA} = (\text{ROA without control}) - (\text{ROA with control})$$

$$= 3.2 - 3.0 = .2$$

$$\text{\% Change in ROA} = \frac{.2}{3.2} = 6\%$$

In the model plant analysis the asset base of $280,000,000 is multiplied by 1/2 to determine an average asset value over the project life of $140,000,000.

The change in ROA that is caused by the addition of controls can be derived by reducing net earnings after tax by the additional after tax expense (a 50 percent tax rate is assumed) of controls, which is $338,000 as derived from Tables 8-33 to 8-45. The control cost for a monohydrate plant with a fluid bed steam tube dryer is used as a worst case since this model plant involves the most costly controls. Next, the total assets must be increased by the average additional investment for controls as shown in Table 8-29, $1,326,000 x 1/2 = $663,000.

The soda ash producers can make one of three reasonable price responses to the additional control costs: Prices can be raised by an amount sufficient to completely pass-through the additional costs. Prices can be raised by an amount to partially pass-through the additional costs, or prices can remain the same and the additional costs can be completely absorbed by the producers.

The most probable response by the producers is to raise prices sufficiently to completely pass-through the additional control costs. Several principal factors suggest this response as the most probable. First, demand for soda ash is inelastic. Second, three of the current five members of the industry are projected to make expansions which will be "new sources", therefore a significant portion of the soda ash industry will be directly affected. Third, the amount by which the price must be increased in order to completely pass-through the control costs is 1 percent, or approximately 67¢ must be added to a $66 per ton sales price. This 67¢ price increase can be compared to price increases of $6 per ton in January of 1979 and $5 per ton in April of 1979.

From the producer's point of view the worst case would be complete absorption of the control costs. In this case the producer's pre-tax profit margin would be reduced by the above mentioned 67¢ per ton. The results of the return on assets analysis show that complete absorption of the control costs changes the after tax return on assets by 6 percent from 3.2 percent to 3.0 percent.

This 6 percent change in ROA is not likely to significantly alter the investment decision for a company which would otherwise make an investment. Also, the impact on ROA of adding controls is reduced significantly as the level of ROA is increased to what might be termed a "normal" level.

8.4.7 Capital Availability for Control Systems

The necessary capital is likely to be available to companies for the purchase of control equipment.

The total capital required for control of a new 1,000,000 ton monohydrate plant with a fluid bed steam tube dryer would add $1,326,000 to an initial investment of $280,000,000, a .5 percent increase. The total capital required for control of a 1,000,000 ton monohydrate plant with a rotary steam tube dryer, or a direct carbonation plant would require an additional initial investment of .4 percent and .2 percent, respectively. This increase in the initial investment is not likely to seriously alter the capital availability situation for a new plant which otherwise can obtain the necessary capital.

The total capital required for control of an expansion of an existing monohydrate model plant with a fluid bed steam tube dryer would add $663,000 to the additional investment of $9,512,000 required for the facilities of interest or 7 percent. The total capital required for control of an expansion of an existing monohydrate plant with a rotary steam tube dryer, or an expansion of a direct carbonation plant would require an additional investment of 5.7 percent and 3.5 percent respectively. It should be noted that the total investment cost for the full added facility would be greater than the estimated costs for the facilities of interest since the facilities of interest are only those processes which require direct controls such as the calcining operations, the rotary steam tube dryer, bleacher, etc. $9,512,000 does not include other equipment required for increased capacity that does not require direct control. Therefore, the 7, 5.7 and 3.5 percent increases are higher than would be actually encountered. Such increases in the initial investment are not likely to seriously alter the capital availability situation for an expansion which could otherwise be financed.

8.5 SOCIO-ECONOMIC IMPACT ASSESSMENT

The purpose of Section 8.5 is to address those tests of maroeconomic impact as presented in Executive Order 12044 and more generally to assess any other significant macroeconomic impacts that may result from the addition of controls.

The economic impact assessment is only concerned with the costs or negative impacts of the controls. The controls will also result in benefits or positive impacts such as cleaner air and improved health for the population, potential increases in worker productivity, increased business for the pollution control manufacturing industry, and so forth. However, the control benefits will not be discussed here.

EXECUTIVE ORDER 12044

Executive Order 12044 provides several criteria for a determination of major economic impact. Those criteria [57] and findings are:

Criterion:

1. Additional annualized costs of compliance that, including capital charges (interest and depreciation), will total $100 million (i) within any one of the first five years of implementation (normally in the fifth year for NSPS), or (ii) if applicable, within any calendar year up to the date by which the law requires attainment of the relevant pollution standard.

Findings:

The controls are projected to apply to three expansions of 500,000 tons each; one monohydrate (rotary dryer), one monohydrate (fluid bed dryer), and one direct carbonation. This will result in respective fifth year annualized costs of $187,000, $338,000, and $193,000 for a total of $718,000.

Criterion:

2. Total additional cost of production of any major industry product or service will exceed 5 percent of the selling price of the product.

Findings:

The controls will add a maximum of 1 percent to the selling price of the product.

Criterion:

3. Net national energy consumption will increase by the equivalent of 25,000 barrels of oil per day.

Findings:

The increase in energy consumption caused by the controls will be equivalent to approximately 55 barrels of oil per day.

Criterion:

4. Additional annual demand will increase or annual supply will decrease by more than 3 percent for any of the following materials by the attainment date, if applicable, or within five years of implementation: plate steel, tubular steel, stainless steel, scrap steel, aluminum, copper, manganese, magnesium, zinc, ethylene glycol, liquified petroleum gasses, ammonia, urea, plastics, synthetic rubber, or pulp.

Findings:

Soda ash is not included in the materials mentioned above. In spite of this, the controls will result in no perceptible change in demand or supply since the control costs are not expected to inhibit investment in new or expanded plants and since the price inelasticity for soda ash is such that a control cost pass-through is not expected to reduce demand.

Additionally, both the small dollar cost of the controls and the inherent economics of the industry, such as; its geographical concentration, the size of the industry members, the stability of supply and demand, the lack of significant foreign natural deposits, et al., preclude the possibility of significant macroeconomic impacts either on a regional or on a national basis. The control costs will not aggravate national inflation, disrupt regional or national employment patterns, or change the U.S. Balance of Payments position

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9. RATIONALE FOR THE PROPOSED STANDARD

9.1 SELECTION OF SOURCE FOR CONTROL

The sodium carbonate industry is one of a number of industries which the Administrator has determined contribute significantly to air pollution (40 CFR 60.16, 44 FR 49222, August 21, 1979). These industries are included in a priority list of sources for which new source performance standards are to be promulgated. This priority list ranks the emission sources on a nationwide basis in terms of quantities of emissions from the source category, the mobility and competitive nature of each source category, and the extent to which each pollutant endangers health and welfare. The sodium carbonate industry ranks 35th out of 59 source categories on this priority list.

Sodium carbonate can be produced by either natural or synthetic processes. In natural processes, sodium carbonate is produced from naturally occurring ores or brines which contain sodium sesquicarbonate, sodium bicarbonate, or sodium carbonate. In synthetic processes, sodium carbonate is produced from sodium chloride and limestone.

The overall growth rate in sodium carbonate production in recent years has been somewhat slow but relatively stable. The Bureau of Mines has projected an annual growth rate of 3 percent per year for the period from 1976 through 1985. Production of sodium carbonate by natural processes has grown more rapidly than this in the last ten years, but much of this growth has been due to replacement of synthetic sodium carbonate production capacity. Since only one synthetic sodium carbonate plant now remains in operation, future growth in natural sodium carbonate production will not be as rapid as it has been over the past ten years.

Standards are being proposed only for natural process sodium carbonate plants because no growth is expected for synthetic sodium carbonate plants. Synthetic sodium carbonate production in the United States has dropped from 4.4 million Mg/yr in 1967 to 1.1 million Mg/yr in 1978, while natural production has grown from 1.6 million Mg/yr to 6.2 million Mg/yr over the same period. Over the past 12 years, nine synthetic sodium carbonate plants were shut down. Only one synthetic sodium carbonate plant is now in operation in the United States.

This decline in synthetic sodium carbonate production has resulted largely from rising energy costs and increasingly stringent water pollution regulations. Production of sodium carbonate by synthetic processes requires about twice as much energy as production by natural processes. Natural process sodium carbonate plants discharge no waste water stream, while synthetic processes discharge an aqueous waste stream containing calcium chloride. Treatment of this waste stream is difficult and expensive. With the exception of the northeast, the market demand for sodium carbonate can now be supplied at the lowest overall production and transportation cost by natural process plants in Wyoming and California.

9.2 SELECTION OF POLLUTANTS AND AFFECTED FACILITIES

9.2.1 Affected Facilities

Particulates are generated in sodium carbonate plants by various processing operations. These operations include dissolving the mined ore and drying and handling the final product. Facilities in natural process sodium carbonate plants for which standards are proposed are calciners, dryers (including predryers), and bleachers. These facilities are all major sources of particulate emissions. Projected emissions from each new facility in 1985 under present levels of control are presented in Table 9-1.

Standards are not being proposed for other emission sources in sodium carbonate plants. First, boilers for steam and power generation in sodium carbonate plants are included within the scope of a program to develop an industrial boiler NSPS. Next, many emission sources, including crushers, grinding mills, screening operations, bucket elevators, conveyor transfer points, bagging operations, storage bins, and fine product (20

TABLE 9-1. PROJECTED EMISSIONS FROM NEW SODIUM CARBONATE PLANTS IN 1985 UNDER PRESENT LEVELS OF CONTROL[a]

Emission Source	Number of Sources	Emissions	
		Mg/yr	Tons/yr
Calciner	2	264	290
Dryer	3	275	303
Predryer	2[b]	123	136
Bleacher	1	36.6	40.2
TOTAL		700	768

[a] Includes emissions from new facilities only; facilities which commenced construction before 1980 are not included. Based on process weight regulation.

[b] There are 2 predryers in a single processing train.

mesh and smaller) loading are included within a program to develop NSPS for generic sources in non-metallic mineral processing plants. Other potential emission sources in sodium carbonate plants include stockpiling, conveying, and windblown dusts. However, these are fugitive sources common to many mineral industries rather than process sources, and a specialized program would be required to identify and study them. For these reasons, process emission sources rather than general fugitive sources were emphasized in this standard development program for the sodium carbonate industry.

Standards for dissolvers and dissolver-crystallizers are also not proposed because they are not significant emission sources. Dissolvers in plants built since about 1973 are currently controlled in order to comply with State opacity regulations or to control internal dusting problems. Emissions from dissolvers are small compared to the other emission sources considered. Under current levels of control, dissolver emissions contribute no more than 2.5 percent of the process emissions from the sodium carbonate industry. Thus, a dissolver emission standard is not proposed because it would have a very small impact on reducing plant emissions. However, if dissolver gases are exhausted through the calciner emission control device, the standard for particulate matter for calciners would apply to the combined gas stream.

In some plants, the exhaust gas from the calciner is recycled to carbonation towers for utilization of the carbon dioxide. Transfer of the exhaust gas requires a fan which must be protected from damage that would result from impaction by particulate matter in the gas stream. For this reason, particulate emissions from calciners are reduced by gas scrubbers before the gas is exhausted to carbonation towers. Emissions are further reduced as the gas passes through the carbonation towers. The remaining particulate emissions from these calciners will thus be very low. Moreover, the use of carbonation towers which utilize calciner exhaust gases is not typical of the industry on a nationwide basis. Thus, a standard is not proposed for these carbonation towers at this time. However, these standards will be reevaluated during the four year review and standards for carbonation towers could be considered if these circumstances are found to change.

9.2.2 Pollutants

All of the facilities for which standards are proposed are major sources of particulate emissions. Small amounts of sulfur oxides and organics are also emitted from direct-fired calciners, but source tests have indicated that these emissions are very low compared to uncontrolled particulate emissions. Sulfur dioxide emissions from a coal fired calciner were measured to be less than 0.0076 kg/Mg (0.015 lb/ton).

Organic emissions from calciners averaged approximately 30 ppm for a coal-fired calciner and 150 to 2,000 ppm for a gas-fired calciner. These emissions were measured by use of a gas chromatograph flame ionization detector and are reported as methane. The actual organic species present were not determined. The organic emissions are believed to result from oil shale which is present in the trona ore, and probably consist of high molecular weight compounds. The actual organic emissions would thus be only a fraction of the reported values. For example, if the organic species are mainly C_6, the emissions in ppm of C_6 would be one-sixth of the emissions reported as ppm of methane. In addition, no control technology has been demonstrated in the sodium carbonate industry for controlling organic emissions. Thus, standards are proposed only for particulate emissions.

9.3 SELECTION OF THE BASIS OF THE PROPOSED STANDARDS

Particulate emissions from sodium carbonate plants can be effectively controlled by conventional add-on particulate control techniques. Source tests conducted at three sodium carbonate plants along with industry data led to the selection of electrostatic precipitators as the best system of emission reduction for calciners and bleachers and venturi scrubbers as the best system for dryers and predryers.

Two alternatives were considered for regulating emissions from sodium carbonate plants. These alternatives are defined in Chapter 6. Under Alternative 1, facilities would be controlled to essentially the same extent as required by the most stringent of existing SIP regulations.

Alternative 2 would set lower emission limits for each individual facility based on the best level of control demonstrated for the facility in the sodium carbonate industry. The emission limits used to conduct the impact analysis for the two alternatives are presented in Table 9-2.

Control techniques capable of achieving the emission limits that would be required under Alternative 2 include electrostatic precipitators (for calciners and bleachers) and venturi scrubbers (for dryers and predryers). The emission levels corresponding to Alternative 2 have been demonstrated using these techniques, but other techniques could also potentially be used to meet these emission levels. In most cases the same type of control technique would be used to meet Alternatives 1 and 2, but venturi scrubbers used to meet Alternative 2 would have higher pressure drops and ESP's would have larger plate areas.

The environmental, energy, and economic impacts of Alternative 1 are based upon typical State Implementation Plan requirements. These requirements establish a baseline for determining the incremental impacts of the proposed standards. However, in Wyoming, where much of the new plant growth is projected, baseline control requirements may be more stringent than SIP controls. During new source review for best available control technology (BACT), the State has recently required new plants to meet emission limits which are almost equivalent to the proposed standards. The potential effect of Wyoming's BACT policy was considered in the analysis of impacts, which are summarized below.

Under Alternative 1, projected particulate emissions from new sodium carbonate plants would reach 700 Mg/yr (768 TPY) by 1985. However, when Wyoming BACT determinations are projected to apply to all new plants in that State, estimated national particulate emissions from new sodium carbonate plants are projected to reach 440 Mg/yr (490 TPY). Under Alternative 2, projected emissions would be 315 Mg/yr (347 TPY) in 1985, which represents a 55 percent reduction in emissions over Alternative 1 (28 percent reduction assuming BACT has been applied to Wyoming plants).

TABLE 9-2. EMISSION LIMITS FOR THE REGULATORY ALTERNATIVES AND THE PROPOSED STANDARD

	Alternative 1 (baseline)[a]		Alternative 2 (basis for standard)		Proposed Standard[b]	
	kg/mg	lb/ton	kg/mg	lb/ton	kg/mg	lb/ton
Calciner	0.15	0.30	0.1	0.2	0.11	0.22
Dryer	0.25[c]	0.50	0.04	0.08	0.045	0.09
Predryer	0.08	0.16	0.04	0.08	0.045	0.09
Bleacher	0.06	0.12	0.02	0.04	0.03	0.06

[a] Based on process weight regulation.

[b] The standard ultimately proposed is slightly less stringent than Alternative 2 upon which the impact analysis was based.

[c] For monohydrate process (Wyoming).

No secondary environmental impacts would result from implementation of either of the regulatory alternatives. Scrubber liquor effluents and particulates recovered in the emission control systems are directly recycled to the process. Thus, there are no liquid or solid waste streams from the emission control equipment which are not contained.

The incremental increase in energy consumption in going from Alternative 1 to Alternative 2 is small in comparison to the total energy required by the process equipment. The largest incremental increase is for the model plant with a fluid bed dryer controlled by a cyclone/venturi scrubber. For this model plant, the increased energy consumption in going from Alternative 1 to Alternative 2 is about 53 TJ per year (5×10^{10} Btu/yr). The energy increase in going from the BACT level to Alternative 2 would be much less. Energy consumption for the entire sodium carbonate plant is about 3700 TJ per year (3.5×10^{12} Btu/yr). Thus, a standard based on Alternative 2 would result in about a 1.4 percent increase in the energy consumption of sodium carbonate plants, and would have a minimal impact on national energy consumption.

Capital costs of about $2.2 to 5.5 million (depending on process configuration) would be required for pollution control equipment to meet Alternative 2 for a typical plant producing 454,000 Mg/yr (500,000 TPY) sodium carbonate. These capital costs are about $240,000 to $690,000 greater than costs required to meet the Alternative 1 control level. Incremental costs to meet the Alternative 2 level over the BACT level would be less since costs to meet the BACT level would be higher than the costs to meet Alternative 1. The total increase in capital cost for all new, modified, or reconstructed plants in 1985 to meet Alternative 2 compared to Alternative 1 is $1.5 million.

The economic impact under Alternative 2 would be minimal. Costs of compliance with the Alternative 2 control levels would result in a price increase for sodium carbonate of one percent (about 66 cents per ton) or less. This increase could be passed on to sodium carbonate consumers without significantly affecting the industry. If the costs were to be absorbed by the producers, the resulting profit reduction would be unlikely to have a major impact on the producer's return on assets.

Based on the reduction in national particulate emissions, the absence of adverse secondary environmental impacts, the minimal energy impacts, and the reasonable economic impact, Alternative 2 was chosen over Alternative 1 as the basis for the proposed standard.

9.4 SELECTION OF THE FORMAT OF THE PROPOSED STANDARDS

Several different formats for the proposed standard were considered. These included percent control, mass per unit time, mass per unit of production, and concentration.

The percent control format provides a direct measurement of the performance of the control equipment, but not of emissions. This format would require more costly performance testing since inlet as well as outlet measurements must be made and would also complicate the test because inlet loadings are high and would be more difficult to measure. This format has no overall advantages relative to alternative formats which could be selected. For these reasons, the percent control format was not selected.

A mass per unit time format (e.g., kg/hr) directly monitors the net quantity of pollutants emitted. However, this format would not allow for variations in unit size or production rate, and large facilities operating at full production would be penalized relative to smaller facilities or facilities operating at a reduced capacity. For this reason, the mass per unit time format was not selected.

A mass per unit of production format also directly monitors the net quantity of pollutants emitted, but also provides flexibility to allow for variations in unit size, production rate, and process parameters such as changes in air flow rates. Enforcement would be somewhat more complicated than for a mass per unit time or concentration standard since this format requires accurate determination of production rate. However, enforcement would be simpler than for the percent control format since inlet testing is not needed. This format would require stricter percent control for facilities with higher inlet emission rates.

A concentration format may be somewhat easier to enforce than a mass per unit of production format since production rate must be monitored only to the extent necessary to ensure that the facility is operating near full capacity during tests. Furthermore, vendors of emission control equipment usually guarantee equipment performance in terms of the pollutant concentration in the discharge gas stream. However, there is also a potential for reducing the effectiveness of a concentration standard by diluting the exhaust gases discharged to the atmosphere with excess air, thus lowering the concentration of pollutants emitted but not the total mass emitted. With direct fired facilities this problem can usually be overcome by correcting the concentration measured in the gas stream to a reference condition such as a specified oxygen or carbon dioxide percentage in the gas stream. However, for steam heated dryers and predryers it would not be possible to correct the concentration to account for dilution by excess air.

The mass per unit of production format was selected as the most suitable format for regulation of particulate emissions from sodium carbonate plants because of its flexibility to allow for variations in unit size, production rates, and air flow rate and its direct relationship to the quantity of particulate emissions. These advantages outweigh the disadvantages associated with the requirement for accurate determination of process weight.

9.5 SELECTION OF EMISSION LIMITS

Facilities at three sodium carbonate plants were tested by EPA to evaluate techniques used for controlling particulate emissions and to quantify the emission control levels achieved. Results of these tests are presented in Appendix C of the Background Information Document. Emission limits for each facility were selected based on the demonstrated performance. The proposed standard is based on Alternative 2 because this results in decreased national particulate emissions and does not impose unreasonable economic and environmental impacts.

Visible emission standards are also proposed for each individual facility. These standards will help to ensure the proper operation and maintenance of the control equipment required to meet the mass emission standards. These opacity standards are not intended to be more restrictive than the mass emission standards, but merely to supplement them.

Because of differences in uncontrolled emission rates, gas flow rates, and gas and particle characteristics, all emission points are not controlled to the same emission level. Thus, separate emission limits were set for calciners, bleachers, and dryers. The rationale for selecting each of the emission limits is discussed below.

9.5.1 Calciners

The proposed emission limit for calciners is 0.11 kg/Mg dry feed and 5 percent opacity. These limits are based on testing of a coal-fired calciner. As shown by data in Chapter 3, coal-fired calciners have higher gas flow rates and uncontrolled particulate rates than gas-fired or steam tube calciners and thus represent the more difficult case for emission control. No other factors were found which might affect the relative control capabilities of an ESP on various types of calciners. For example, calciners used in the different natural processes for producing sodium carbonate generally have feeds with similar chemical compositions. The chemical reactions which occur in the calciners are also similar. Particle size analyses indicated no significant difference in the particle size distribution of particulates emitted from various calciners. These factors notwithstanding, data collected by EPA on gas-fired calciners showed emissions exceeding the standard. However, the units tested were older than the coal-fired calciner tested and, as explained later, are not considered to be representative of well-designed and operated control systems. Based on these findings, the Administrator has concluded that any calciner used in natural process sodium carbonate plants would be capable of meeting the proposed emission level.

The average emission level determined in EPA tests of a coal-fired calciner (including vented dissolver emissions) controlled by a cyclone/ESP was 0.101 kg/Mg dry feed. The calciner was operated at greater than 90 percent of normal operating capacity during these tests. Tests conducted by industry have shown emission levels of 0.014, 0.031 and 0.072 kg/Mg for coal-fired calciners controlled by cyclones/ESP's.

Tests were also conducted by EPA on two gas-fired calciners. Results of these tests are reported in Appendix C. These tests indicated emission levels higher than the proposed standards. However, the control equipment used at these calciners does not represent the best available control technology. One of the calciners was controlled by a cyclone in series with an electrostatic precipitator. During the source tests, the first two fields of the four field ESP had low currents and voltages and high spark rates compared to the other two fields. Thus, the test results were not representative of what could be achieved with a properly functioning ESP. The other gas-fired calciner tested was controlled by a cyclone in series with a venturi scrubber. The venturi scrubber was operated with an average pressure drop of about 85 cm (33 in.) of water. At this pressure drop, a venturi scrubber will not achieve a removal efficiency comparable to a four field ESP.

During these EPA source tests, the coal-fired calciner was observed to have zero opacity most of the time. Emissions with zero opacity were observed during 210 minutes of the total observation period of 330 minutes (64 percent of the time). The maximum 6-minute average opacity level observed during the remainder of the observation period was only 3 percent.

Sodium carbonate plant operating personnel have reported that an intermittent bluish haze has been observed at the exhaust of a few calciners. It is suspected that this haze could be caused by the light-scattering properties of either fine organic aerosol droplets or particulate matter. The blue haze was not visible during the opacity observations made during the source tests and the opacity standards were not developed with an adjustment for blue haze conditions. Thus, enforcement of the opacity standard may not be appropriate during periods when the blue haze is visible. Should this haze cause a facility that is meeting the mass emission standard to violate the opacity standard, the owner or operator of such a calciner can petition the Administrator for a higher opacity standard if certain conditions are met. The procedure is described in 40 CFR 60.111(e).

9.5.2 Dryers and Predryers

An emission limit of 0.045 kg/Mg dry product (0.09 lb/ton) and 10 percent opacity is proposed for all types of dryers and predryers. EPA test data indicate that rotary steam tube dryers, fluid bed steam tube dryers, and rotary steam heated predryers can all meet the proposed emission limit. No EPA test data were obtained on gas-fired dryers, but gas-fired dryers are currently in use at only one sodium carbonate plant, and new gas-fired dryers are not expected.

Average emission levels determined in EPA source tests were as follows: 0.035 kg/Mg dry product for a rotary steam tube dryer controlled by a venturi scrubber, 0.04 kg/Mg dry product for a fluid bed dryer controlled by a cyclone/venturi scrubber, and 0.026 kg/Mg dry product for a predryer controlled by a cyclone/venturi scrubber. During these tests, the rotary steam tube dryer was operated at greater than 90 percent of design capacity, and the fluid bed steam tube dryer was operated at greater than 80 but less than 90 percent of normal operating capacity, but calculations indicate that emissions from predryers at full capacity would be 0.04 kg/Mg or less. (See Section 4.3.1.5).

During these EPA source tests the rotary steam tube dryer controlled by a venturi scrubber was observed to have no visible emissions during a total test time of 240 minutes. The rotary steam heated predryer was also observed to have no visible emissions during a total test time of 360 minutes. The fluid bed dryer controlled by a cyclone/venturi scrubber was observed to have no visible emissions greater than 10 percent opacity during 120 minutes of testing. All observed six-minute average opacities were between 6 and 10 percent during the testing.

9.5.3 Bleachers

An emission limit of 0.03 kg/Mg dry feed and 5 percent opacity is proposed for bleachers. The average emission level achieved in EPA tests of a gas-fired bleacher controlled by a cyclone/ESP was 0.021 kg/Mg dry feed. During these EPA source tests the bleacher was observed to have no visible emissions during a total test time of 360 minutes.

The ESP tested by EPA was designed to treat emissions from three bleachers in a single unit. Only two of the bleachers were in operation during the source tests, and these bleachers were operated at greater than 65 percent but less than 90 percent of design capacity. However, the actual gas flow rate to the ESP during the source test was more than 90 percent of the design flow rate of the ESP. Since the efficiency of an ESP depends upon the ratio of gas flow rate to plate area (according to the Deutsch Anderson equation), the efficiency measured during these source tests would be comparable to the efficiency that would be achieved by a properly designed ESP at full capacity. Calculations indicate that emissions from the bleachers at full capacity would be 0.026 kg/Mg or less. (See Section 4.3.1.2.)

9.6 MODIFICATION/RECONSTRUCTION CONSIDERATIONS

EPA has reviewed the most likely changes that could occur in sodium carbonate plants which could potentially be modifications. Each of these changes would be made to increase production rate. These changes would be (1) the installation of larger fans on a dryer and (2) the modification to a combustion chamber of a calciner to allow increased fuel consumption. Because a capital expenditure would be required and an increase in particulate emissions would probably result, these would probably be classified as modifications unless emissions were reduced to their former levels.

If these changes occur on a calciner or dryer controlled by a venturi scrubber, the scrubber pressure drop could be increased to provide increased particulate removal so that the controlled particulate emission rate would not increase. In this case the change would not subject the facility to the NSPS.

These modifications are not expected to be common. They would occur as part of an expansion where increased throughput would be possible in the remainder of the processing train so that modifying the dryer or calciner to allow increased throughput would increase the production rate of the entire plant process operation. Because these modifications are not expected to be common, and there are potential ways to compensate if they do occur, no special allowance or exemptions are made in the standards for these modifications.

Another change which could potentially result in a modification is the conversion of an existing gas or oil-fired calciner to coal firing. Because converting the calciner to coal would require the calciner to be derated to a lower production rate, the actual mass rate of emissions from the calciner might not be increased in converting from gas to coal. In that case, the change would not subject the calciner to NSPS. If, however, the mass emission rate is increased above State emission standards, improvements to the control device would be necessary. The additional cost to bring emissions back to their former levels to prevent a modification or at most comply with NSPS would be similar to the incremental cost for compliance by new facilities.

9.7 SELECTION OF MONITORING REQUIREMENTS

Under Section 114(a) of the Clean Air Act, the Administrator may require the owner or operator of any stationary emission source to install, use, and maintain monitoring equipment or methods. EPA has exercised this authority in the standards of performance for several source categories by requiring the monitoring of pollutant emissions or parameters that are indicators of pollutant emissions. The requirements for continuous monitoring are necessary to determine if a control device is being properly operated and maintained. It also aids in determining when and if a performance test should be required.

Opacity monitoring systems are perhaps the most reasonable and effective means of determining proper operation and maintenance of cyclone/ESP and fabric filter emission control systems. Results of opacity monitoring are not used to judge compliance with particulate matter or opacity standards. However, if high opacity readings are recorded, they would be justification for requiring performance tests using Method 5 or Method 9. The opacity monitoring systems are substantially less costly and more easily applied than periodic mass emissions tests for particulate matter. Therefore, the use of a continuous opacity monitoring system is proposed as a requirement.

Entrained water droplets can prevent the accurate measurement of opacity of the gas from wet scrubber systems. However, monitoring the pressure drop across the scrubber and the fluid flow rate to the scrubber are reasonable and effective means of determining proper operation and maintenance of wet scrubbers. The scrubbing fluid flow rate may be monitored by measuring either the scrubbing fluid supply pressure or by measuring the scrubbing fluid supply flow rate directly. If the scrubbing fluid supply pressure is monitored, the pressure sensor must be located at a point where there are no valves between it and the scrubber. Thus, at facilities with wet scrubber systems the proposed regulation would require monitoring of scrubber pressure drop and scrubbing fluid flow rate or supply pressure rather than monitoring of opacity.

Monitoring records must be maintained to be used in preparing quarterly excess emission reports and so that they will be available for review by enforcement personnel. Excess opacity measurements must be reported or, when opacity monitoring is not applicable, any one hour period for which the average scrubber pressure drop or scrubbing fluid flow rate is less than 90 percent of the average level maintained during the most recent performance test in which the facility demonstrated compliance with the particulate standard must be reported.

9.8 SELECTION OF PERFORMANCE TEST METHODS

The use of EPA Reference Method 5, "Determination of Particulate Emissions from Stationary Sources" (Appendix A, 40 CFR 60, Federal Register, December 2, 1971) is required to determine compliance with the mass standards for particulate matter emissions. Results of performance tests using Method 5 conducted by EPA at three existing sodium carbonate plants comprise a major portion of the data base used in the development of the proposed standard. EPA Reference Method 5 has been shown to provide a representative measurement of particulate matter emissions, and would be used for determining compliance with the proposed standards.

Calculations applicable under Method 5 necessitate the use of data obtained from three other EPA test methods conducted previous to the performance of Method 5. Method 1, "Sample and Velocity Traverse for

Stationary Sources" must be conducted in order to obtain representative measurements of pollutant emissions. The average gas velocity in the exhaust stack is measured by conducting Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)." The analysis of gas composition is measured by conducting Method 3, "Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight." These three tests provide data necessary in Method 5 for converting volumetric flow rate to mass flow rate. In addition, Method 4, "Determination of Moisture Content in Stack Gases" is suggested as a better choice for determination of moisture content than the estimation procedure under Method 5.

All observations for determining compliance with opacity standards would be made in accordance with the procedures established in EPA Method 9 for stack emissions. This method requires that a more representative six-minute average of opacity observations rather than a single observation be used to determine compliance.

Since the proposed standards are expressed as mass of emissions per unit mass of feed to or product from a facility, it would be necessary to quantify the mass rate of the feed or the product. The proposed regulation would require that weigh scales be installed at the feed end of calciners and bleachers and at the product end of dryers and predryers unless the owner or operator of the source can present a method for indirectly calculating these feed or product rates to an accuracy which the Administrator determines is satisfactory.

9.9 IMPACTS OF REPORTING REQUIREMENTS

The proposed standards will require reports for notification of construction, anticipated start-up, actual initial start-up, and physical or operational changes. In addition, a performance test to determine compliance and a demonstration of a continuous monitoring system will be required for each emission source. Reports giving notification prior to these tests and a report of the tests will be required. Excess emission reports will be required four times a year. The operator will be required to maintain records of any start-ups, shut-downs, and malfunctions of the control equipment or the continuous monitoring system. A file of all measurements as described in Section 60.7(d) of the General Provisions must also be maintained.

The total labor requirements for all respondents to collect and prepare the required data during the first five years of the standard is approximately 8,446 hours.

APPENDIX A

EVOLUTION OF THE PROPOSED STANDARDS

The purpose of this study was to develop New Source Performance Standards for the Sodium Carbonate Industry. Work on the study was begun in April, 1978 by Radian Corporation under the direction of the Office of Air Quality Planning and Standards (OAQPS), Emission Standards and Engineering Division (ESED). The initial step of the study was a screening study which concluded in October, 1978, with the recommendation that NSPS be developed for the Sodium Carbonate Industry. Work then began on Phase II of the study.

The chronology which follows lists the important events which have occurred in the development of background information for New Source Performance Standards for the Sodium Carbonate Industry.

Date	Activity
April, 1978	Screening study initiated
October 13, 1978	Screening study (Phase I) completed. A decision was made to initiate standards development.
December 20, 1978	Preliminary source test plan submitted.
January, 1979	Phone contacts with sodium carbonate plants conducted.
January 31, 1979	Initial source test request submitted.
February 15, 1979	Plant visit to Texasgulf, Inc. in Granger, Wyoming.
February 20, 1979	Plant visit to Kerr-McGee Chemical Corp. in Trona, California.
February 21, 1979	Plant visit to FMC Corporation in Green River, Wyoming.
February 22, 1979	Plant visit to Stauffer Chemical in Green River, Wyoming.
February 28, 1979	Final source test request submitted.
March 30, 1979	Preliminary model plants submitted.
May 14-20, 1979	Emission tests at Plant A.
May 21-24, 1979	Emission tests at Plant B.
June 29, 1979	Final model plant parameters submitted.
June, 1979	Preliminary results of source tests at Plants A and B received.
July 16-21, 1979	Emission tests at Plant C.

Date	Activity
August 3, 1979	Cost analysis submitted.
August, 1979	Draft reports of source test results of Plants A and B received.
August 10, 1979	Meeting to discuss basis for standards.
September, 1979	Results of source tests at Plant C received.
December 7, 1979	Working Group package mailed.
December 7, 1979	BID Chapters 3-8 mailed to industry representatives for review.
January 31, 1980	NAPCTAC package transmitted to committee members. Industry and external group review packages mailed.
February 12, 1980	Steering Committee package mailed.
February, 1980	Docket transmitted to Washington, D.C.
February 28, 1980	NAPCTAC meeting.

APPENDIX B

INDEX TO ENVIRONMENTAL CONSIDERATIONS

This appendix consists of a reference system which is cross indexed with the October 21, 1974 Federal Register (39 FR37419) containing EPA guidelines for the preparation of Environmental Impact Statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the Federal Register guidelines.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Background Information Document (BID)
1. Background and Description of Proposed Action	
Summary of Proposed Standard	The standards are summarized in Chapter 1, Section 1.1.
Statutory Basis for the Standard	The statutory basis for the standard is given in Chapter 1, Section 1.1.
Facilities Affected	A description of the facilities to be affected is given in Chapter 3, Section 3.2.
Process Affected	A description of the processes to be affected is given in Chapter 3, Section 3.1.
Availability of Control Technology	Information on the availability of control technology is given in Chapter 4.
Existing Regulations at State or Local Level	A discussion of existing regulations on the industry to be affected by the standards is included in Chapter 3, Section 3.3.
2. Alternatives to the Proposed Action	
Alternatives 1,2	
Definition of alternatives	The definitions of alternatives 1,2 are presented in Chapter 6, Section 6.2.

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Background Information Document (BID)
Environmental Impacts	
Air Pollution	The air pollution impact of the control alternatives are considered in Chapter 7, Section 7.1.
Water Pollution	The impact of the control alternatives on water pollution are considered in Chapter 7, Section 7.2.
Solid Waste Disposal	The impact of the control alternatives on solid waste disposal are considered in Chapter 7, Section 7.3.
Energy	The impact of the control alternatives on energy use are considered in Chapter 7, Section 7.4.
Other Impacts	Other impacts associated with the control alternatives are evaluated in Chapter 7, Sections 7.5 and 7.6.
Costs	The impact of the control alternatives on costs are considered in Chapter 8, Section 8.2.

APPENDIX C - SUMMARY OF TEST DATA

This appendix presents the results of the particulate emission tests and the visible emission measurements conducted at three different plants. Results of organic emission measurements conducted at two of these, and SO_2 measurements conducted at one plant are also presented.

The three plants where tests were conducted are identified as Plants A, B, and C. The facilities tested at each plant were as follows:

1. Plant A
   a. coal fired calciner and dissolver jointly controlled with combined cyclone/ESP
   b. rotary steam tube dryer with venturi scrubber
2. Plant B
   a. gas fired calciner with combined cyclone/ESP
   b. gas fired calciner with combined cyclone/venturi scrubber
   c. fluid bed steam tube dryer with combined cyclone/venturi scrubber
3. Plant C
   a. rotary steam heated predryer with combined cyclone/venturi scrubber
   b. gas fired bleacher with combined cyclone/ESP

EPA Test Method 5 was used to determine the particulate concentration in the gas entering and leaving the control equipment of each facility. EPA Test Methods 1 through 4 were used to determine other characteristics of the gas stream required for the calculations applicable under Method 5. Three particulate tests were performed at both the inlet and the outlet of each emission control system with the exception of the combined coal fired calciner-dissolver system, where three tests were made on the outlet emissions, but only two tests were made on the inlet gas stream. The results of these tests are presented in Tables C-1 to C-4, C-7 to C-12 and C-16 to C-21.

Particle size distributions were determined at the inlet and outlet of the control equipment for each facility with the following exceptions;

1) Particle size distributions were not determined at the outlet of the venturi scrubbers on the dryers at either Plant A or Plant B due to the high moisture content of the exhaust gas.

2) A particle size distribution analysis was not performed at the outlet of the coal-fired calciner in Plant A.

These particle size tests were performed using an Andersen Cascade Impactor. A Bacho size analysis was also performed on a composite sample of collected particulates from the inlet tests. The results of these measurements are presented in Figures C-1 to C-20.

Visible emission measurements were conducted according to EPA Test Method 9. The results of these measurements are presented in Tables C-5, C-6, C-13 to C-15, C-22 and C-23.

The concentration of organics in the gas stream entering and leaving the control equipment was determined for the calciners at Plants A and B. Organics were analyzed on the basis of total hydrocarbons as methane using a gas chromatograph. These results are summarized in Tables C-1, C-3, and C-7 to C-12.

SO_2 measurements were conducted at the inlet and outlet of the cyclone/ ESP on the coal fired calciner in Plant A using EPA Test Method 6. Three tests were completed on the outlet but only one inlet test was completed. The results are presented in Tables C-1 and C-2.

C.1 DESCRIPTION OF FACILITIES

Plant A. The coal fired calciner tested was controlled by a cyclone and an ESP. Dissolver emissions in addition to the calciner emissions are vented to this control equipment. The dissolver serves two trains and the dissolver gas is vented to the control equipment of both calciners. However, the gas flow rate and particulate rate from the dissolver are very small in comparison to the gas flow and particulates from the calciner.

The calciner was operated at greater than 90 percent of normal operating capacity during the tests. No abnormalities in the calciner operating parameters were noted during the tests. During the second and third EPA Method 5 tests the first collection field in the ESP was not functioning. The average voltage and d.c. current in the first field when it was operating were below normal. The remaining fields in the ESP were operating normally throughout the tests. Plant personnel reported that the first field was frequently out of service and that previous tests had been conducted with it out.

The rotary steam tube dryer was operated at greater than 90 percent of the design capacity during the tests. No abnormalities in the dryer operating parameters were noted during the tests.

Plant B. The calciner controlled by a cyclone/ESP was operated at greater than 90 percent of normal operating capacity during testing. No abnormalities in calciner operating parameters were noted while testing was underway. However, abnormalities were noted in the operating parameters of the first two fields of the ESP. The first field had an average voltage of 144 volts and a d.c. current of 0.03 amps. The second field had an average voltage of 204 volts and a d.c. current of 0.09 amps. For both of these fields the voltage and current indicators showed wide fluctuations. The third and fourth fields operated with voltages of 310 and 261 volts respectivley and d.c. currents of 0.45 and 0.71 amps respectively. The first two fields also had high spark rates. Spark rates for the first and second fields were approximately 50 and 55 sparks per minute, while for the third and fourth fields spark rates were less than 10 per minute. As a result of the abnormalities in ESP operation, the test results at the ESP outlet are not representative of what can be achieved with a properly functioning ESP.

The gas fired calciner controlled by a cyclone/venturi scrubber operated at greater than 75 percent of normal operating capacity during testing and no abnormalities in calciner operating parameters were noted. This cyclone/venturi scrubber system was operated at an average pressure drop of 94 cm (37") of water (approximately 85 cm (33.5") for the venturi alone) and with an average L/G ratio of 0.44 l/m^3 (3.3 gal/1000 acf). At this pressure drop the venturi scrubber will not achieve as high a removal efficiency as a four state ESP. As noted in Chapter 4, a pressure drop of 150 cm (60") of water may be needed in a venturi scrubber to achieve a removal efficiency comparable to that achieved by a four stage ESP. Thus, the venturi scrubber at a pressure drop of 85 cm water does not represent best available control technology.

The fluid bed dryer was operated at greater than 80 percent but at less than 90 percent of normal operating capacity during the tests. No abnormalities in dryer operating parameters were noted during any of the tests with the exception of the first Method 5 test. During the initial part of the first Method 5 test a lower than normal operating pressure in the freeboard above the bed was noted. Also, a slightly higher amperage was drawn by the dryer fluidizing air fans during the first Method 5 test relative to the amperage these fans drew during the second and third Method 5 tests. These differences in operating conditions between the first test and the second and third tests may explain the large difference in particulate emission results between the first test and the second and third tests. The cyclone/venturi scrubber was operated at a pressure drop of about 96 cm (38") of water (approximately 35" of water for the venturi scrubber alone) during all tests.

Plant C. The emission control system for the predryers consists of a cyclone for each predryer, and one venturi rod scrubber for every two predryers. Thus, the exhaust gas from each predryer cyclone is combined with the exhaust gas from one other predryer cyclone, and this combined stream is treated in a single venturi rod scrubber. Because of this arrangement, the inlets to two cyclones were tested while only one venturi scrubber exhaust was tested. The two predryers were operated at greater than 60 percent but less than 85 percent of their design capacity. On several occasions, predryer equipment failure occurred while testing was underway. When these failures occurred, the tests were stopped until the equipment was brought back on line and reached steady state operating condition. However, after an equipment failure which occurred prior to the first run of an EPA Method 5 test at the inlet to the emissions control equipment on the first predryer, testing was started before the equipment had reached steady state operating conditions. As a result, the test results from this run were in error and will not be used in subsequent analyses.

The cyclone/venturi scrubber system was operated at a pressure drop of 46 cm (18") of water (about 43 cm (17") of water for the venturi alone). Ambient air is admitted at the inlet to the venturi rod scrubber for process control reasons. This ambient air accounts for the difference between the value of the outlet gas flow from the scrubber and the value obtained by adding the gas flow rates measured at the outlet of each predryer.

The emission control scheme for the bleachers consists of one ESP simultaneously treating emissions from three bleachers. Each bleacher is serviced by a separate cyclone. Two of the three bleachers were operating during the tests. Thus, the inlets to two cyclones were tested along with the exhaust from the one ESP. The two bleachers which were operational during testing were operated at greater than 65 percent but less than 90 percent of design capacity. The gas flow rate to the emission control equipment on the bleacher was actually higher than the design gas flow rate on a dry standard basis, and only slightly less than design rate on an actual basis. This is due to the admission of ambient air between the bleachers and the emission control equipment. (This ambient air is emitted for process control reasons.)

TABLE C-1. PLANT A: SUMMARY OF EMISSION TEST RESULTS, COAL FIRED CALCINER INLET TO CYCLONE/ESP

Test no.	One	Two	Average
General Data			
Date	5/23	5/24	-
Time	1115-1250	0800-1035	-
Isokinetic ratio (%)	90.4	92.8	91.6
Gas Data			
Temperature (°C)	205	198	202
Temperature (°F)	401	388	395
Moisture (%)	19.8	21.5	20.6
Particulate Emissions			
g/Nm^3 (dry)	117	122	119
Gr/dscf	51.2	53.1	52.2
kg/Mg feed	191	205	198
lb/ton feed	383	410	396
SO_2 Emissions			
ppm		0.007	
lbs/ton feed		0.014	
Organic emissions			
ppm	30	22	26

TABLE C-2. PLANT A: SUMMARY OF EMISSION TEST RESULTS, COAL FIRED CALCINER OUTLET FROM CYCLONE/ESP

Test no.	One	Two	Three	Average
General Data				
Date	5/23	5/23	5/24	-
Time	0848-1250	1620-1804	0807-0954	-
Isokinetic ratio (%)	99.3	101	104	102
Gas Data				
Temperature (C°)	207	205	206	206
Temperature (F°)	404	401	403	403
Moisture (%)	17.6	16.9	18.4	17.6
Particulate emissions				
g/Nm^3 (dry)	0.0779	0.0615	0.0157	0.0517
gr/dscf	0.0340	0.0269	0.00684	0.0226
kg/Mg feed	0.154	0.121	0.0284	0.101
lb/ton feed	0.307	0.241	0.0568	0.202
removal efficiency	99.9	99.9		
SO_2 Emissions				
ppm	0.0038	0.00385	0.00345	0.0037
lb/ton feed	0.0076	0.0077	0.0069	0.0074
Organic emissions				
ppm	28	32	-	30

TABLE C-3. PLANT A: SUMMARY OF EMISSION TEST RESULTS
ROTARY STEAM TUBE DRYER - INLET TO VENTURI SCRUBBER

Test no.	One	Two	Three	Average
General data				
Date	5/21	5/21	5/21	-
Time	1545-1705	1745-1905	0935-1200	-
Isokinetic ratio (%)	147	149	121	139
Gas data				
Temperature (°C)	86.1	86.0	86.9	86.3
Temperature (°F)	187	187	189	187
Moisture (%)	52.7	51.1	61.1	55.0
Particulate emissions				
g/Nm^3 (dry)	73.8	68.6	76.9	73.1
Gr/dscf	32.3	30.0	33.6	32.0
kg/Mg dry product	34.2	31.9	33.8	33.3
lb/ton dry product	68.4	63.8	67.6	66.6

TABLE C-4. PLANT A: SUMMARY OF EMISSION TEST RESULTS ROTARY STEAM-TUBE DRYER -OUTLET FROM VENTURI SCRUBBER

Test no.	One	Two	Three	Average
General data				
Date	5/21	5/21	5/22	-
Time	1440-1543	1742-1845	0916-1018	-
Isokinetic ratio (%)	111	94.2	116	107.0
Gas data				
Temperature (°C)	71.1	71.1	71.6	71.3
Temperature (°F)	160	160	161	160
Moisture (%)	44.8	31.7	52.3	42.9
Particulate emissions				
g/Nm^3 (dry)	0.0840	0.0973	0.0788	0.0867
Gr/dscf	0.0367	0.0425	0.0344	0.0379
kg/Mg dry product	0.0325	0.0483	0.0343	0.0384
lb/ton dry product	0.0649	0.0966	0.0686	0.0767
Removal efficiency (%)	99.9	99.9	99.9	

TABLE C-5. PLANT A: SUMMARY OF OPACITY OBSERVATIONS
COAL FIRED CALCINER - CYCLONE/ESP

Date	Time	6-minute interval	Average opacity %
5/23/79	1118-1218	1	3
		2	2
		3	3
		4	2
		5	0
		6	2
		7	0
		8	2
		9	1
		10	2
	1218-1248	1	3
		2	2
		3	2
		4	2
		5	2
		6	0
		7	-
		8	-
		9	-
		10	-

TABLE C-5 (CONTINUED). PLANT A: SUMMARY OF OPACITY OBSERVATIONS COAL FIRED CALCINER - CYCLONE/ESP

Date	Time	6-minute interval	Average opacity %
	1612-1712	1	2
		2	3
		3	1
		4	0
		5	0
		6	0
		7	2
		8	1
		9	1
		10	1
	1712-1812	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-5 (CONTINUED). PLANT A: SUMMARY OF OPACITY OBSERVATIONS COAL FIRED CALCINER - CYCLONE/ESP

Date	Time	6-minute interval	Average opacity %
5/24/79	0815-0915	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	0915-1015	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-6. PLANT A: SUMMARY OF OPACITY OBSERVATIONS ROTARY STEAM TUBE DRYER - VENTURI SCRUBBER

Date	Time	6-minute interval	Average opacity %
5/21/79	1515-1614	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	1615-1715	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-6 (CONTINUED). SUMMARY OF OPACITY OBSERVATIONS
ROTARY STEAM TUBE DRYER - VENTURI SCRUBBER

Date	Time	6-minute interval	Average opacity %
5/22/79	0900-1000	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	1000-1100	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-7. PLANT B: SUMMARY OF EMISSION TEST RESULTS GASFIRED CALCINER INLET TO C/ESP

Test no.	1	2	3	Average
General Data				
Date	5/19	5/19	5/19	-
Time	1015	1430	1710	-
Isokinetic ratio (%)	78.1	93.2	104	91.9
Particulate Emissions				
kg/Mg feed	215	191	133	180
Lb/ton feed	429	382	266	359
Organics				
ppm	47	178	222	149

TABLE C-8. PLANT B: SUMMARY OF EMISSION TEST RESULTS
GAS-FIRED CALCINER - OUTLET FROM C/ESP

Test no.	1	2	3	Average
General Data				
Date	5/19	5/19	5/19	-
Time	1014	1420	1710	-
Isokinetic ratio (%)	94.9	103	108	102
Gas Data				
Temperature (°C)	205	205	205	205
Temperature (°F)	401	401	401	401
Moisture (%)	30.4	30.4	34.3	31.7
Particulate Emissions				
g/Nm^3 (dry)	0.213	0.282	0.187	0.228
Gr/dscf	0.0932	0.123	0.0819	0.0994
kg/Mg feed	0.157	0.206	0.123	0.162
Lb/ton feed	0.313	0.411	0.246	0.323
Removal efficiency	99.90	99.9	99.9	
Organics				
ppm	361	314	-	338

TABLE C-9. PLANT B: SUMMARY OF EMISSION TEST RESULTS
GAS-FIRED CALCINER - INLET TO CYCLONE/VENTURI SCRUBBER

Test no.	1	2	3	Average
General Data				
Date	5/15/79	5/15/79	5/17/79	-
Time	0925	1345	0810	-
Isokinetic ratio (%)	97.6	97.9	111.1	102.2
Particulate Emissions				
kg/Mg feed	156	227	182	188
Lb/ton feed	311	454	364	376
Organics[a]				
ppm	917	2590	-	1750

[a] These organic measurements were made with the calciner operating at low capacity, and may not be representative of normal operation.

TABLE C-10. PLANT B: SUMMARY OF EMISSION TEST RESULTS GAS-FIRED CALCINER - OUTLET FROM CYCLONE/VENTURI SCRUBBER

Test no.	1	2	3	Average
General Data				
Date	5/15/79	5/15/79	5/17/79	-
Time	0930	1337	0800	-
Isokinetic ratio (%)	108	108	108	108
Gas Data				
Temperature (°C)	66.9	76.0	65.6	69.5
Temperature (°F)	153	169	150	157
Moisture (%)	32.8	36.4	38.6	36.0
Particulate Emissicns				
g/Nm^3 (dry)	0.214	0.278	0.269	0.254
Gr/dscf	0.0935	0.122	0.117	0.111
kg/Mg feed	0.15	0.216	0.182	0.183
Lb/ton feed	0.299	0.432	0.363	0.365
Removal efficiency (%)	99.9	99.9	99.9	
Organics [a]				
ppm	154	261	-	208

[a] These organic measurements were made with the calciner operating at low capacity, and may not be representative of normal operation.

TABLE C-11. PLANT B: SUMMARY OF EMISSION TEST RESULTS FLUID BED STEAM TUBE DRYER - INLET TO CYCLONE/VENTURI SCRUBBER

Test no.	1	2	3	Average
General Data				
Date	5/18/79	5/18/79	5/18/79	-
Time	0835	1220	1530	-
Isokinetic ratio (%)	72.6	68.8	76.2	72.5
Particulate Emissions				
kg/Mg feed	115	52.5	51.4	73.1
Lb/ton feed	231	105	103	146
Organics				
ppm	25.0	88.0	-	56.5

TABLE C-12. PLANT B: SUMMARY OF EMISSION TEST RESULTS
FLUID BED STEAM TUBE DRYER - OUTLET FROM CYCLONE/VENTURI SCRUBBER

Test no.	1	2	3	Average
General Data				
Date	5/18	5/18	5/18	-
Time	0841	1220	1520	-
Isokinetic ratio (%)	99.2	99.9	94.9	98.0
Gas Data				
Temperature (°C)	73.9	75.9	61.2	70.3
Temperature (°F)	165	169	142	159
Moisture (%)	31.3	30.0	29.2	30.2
Particulate Emissions				
g/Nm^3 (dry)	0.113	0.0390	0.150	0.0556
Gr/dscf	0.0494	0.0170	0.00655	0.0243
kg/Mg feed	0.081	0.0271	0.0109	0.0397
Lb/ton feed	0.162	0.0542	0.0217	0.0793
Removal efficiency(%)	99.98	99.91	99.96	
Organics				
ppm	103	72	-	87.5

TABLE C-13. PLANT B: SUMMARY OF OPACITY OBSERVATIONS
GAS FIRED CALCINER - CYCLONE/ESP

Date	Time	Six-Minute Interval	Average Opacity (%)
5/19/79	1532-1632	1	13
		2	12
		3	13
		4	17
		5	16
		6	24
		7	17
		8	10
		9	9
		10	13
5/19/79	0945-1045	1	12
		2	13
		3	14
		4	14
		5	13
		6	14
		7	12
		8	11
		9	12
		10	12

TABLE C-14. PLANT B: SUMMARY OF OPACITY OBSERVATIONS
GAS FIRED CALCINER - CYCLONE/VENTURI SCRUBBER

Date	Time	Six-Minute Interval	Average Opacity (%)
5/15/79	1340-1440	1	50
		2	40
		3	45
		4	50
		5	45
		6	40
		7	40
		8	40
		9	38
		10	38

TABLE C-15. PLANT B: SUMMARY OF OPACITY OBSERVATIONS
FLUID BED STEAM TUBE DRYER - CYCLONE/VENTURI SCRUBBER

Date	Time	Six-Minute Interval	Average Opacity (%)
5/19/79	1203-1303	1	6
		2	7
		3	7
		4	7
		5	9
		6	8
		7	8
		8	10
		9	8
		10	7
5/18/79	1410-1510	1	10
		2	8
		3	7
		4	9
		5	6
		6	9
		7	10
		8	8
		9	7
		10	8

TABLE C-16. PLANT C: SUMMARY OF EMISSION TEST RESULTS

Predryer-Inlet to Cyclone/Venturi Scrubber

Test No.	1[a]	2	3	Average[b]
General Data		Cyclone Inlet No.1		
Date	7/19/79	7/20/79	7/21/79	--
Time	1715	1045	1015	--
Isokinetic ratio (%)	102.6	106	105.9	106
Gas Data				
Temperature (°C)	46.7	48.9	53.3	51.1
Temperature (°F)	116	120	128	124
Moisture (%)	4.3	4.4	5.0	4.7
Particulate Emissions				
g/Nm^3 (dry)	8.17	0.620	0.281	0.451
Gr/dscf	3.57	0.271	0.123	0.197
kg/Mg feed	--	1.12	0.499	0.810
Lb/ton feed	--	2.24	0.998	1.62

---

a. This test was discarded due to a low moisture content of the dried product.

b. This average includes only tests 2 and 3.

TABLE C-17. PLANT C: SUMMARY OF EMISSION TEST RESULTS

Predryer-Inlet to Cyclone/Venturi Scrubber

Test No.	1	2	3	4	Average
General Data	Cyclone Inlet No.2				
Date	7/19/79	7/19/79	7/20/79	7/21/79	--
Time	1147	1540	1100	1035	--
Isokinetic ratio (%)	91.1	80.1	93.7	92.6	89.4
Gas Data					
Temperature (°C)	43.3	43.3	43.3	45.0	43.7
Temperature (°F)	110	110	110	113	111
Moisture (%)	6.1	5.3	6.2	5.4	5.75
Particulate Emissions					
g/Nm^3 (dry)	0.261	0.483	1.49	1.43	0.916
Gr/dscf	0.114	0.211	0.653	0.625	0.401
kg/Mg Feed	0.419	0.855	3.15	3.21	1.91
Lb/ton feed	0.838	1.71	6.29	6.42	3.81

TABLE C-18. PLANT C: SUMMARY OF EMISSION TEST RESULTS

Predryer-Outlet From Cyclone/Venturi Scrubber

Test No.	1[a]	2	3	4[b]	Average [c]
General Data	7/19/79	7/20/79	7/20/79	4/21/79	--
Time	1040	1200	2025	0928	--
Isokinetic ratio (%)	100.3	105.9	106.2	105.1	104
Gas Data					
Temperature (°C)	44.4	41.7	43.9	44.4	43.3
Temperature (°F)	112	107	111	112	110
Moisture (%)	4.1	4.5	6.6	6.2	5.77
Particulate Emissions					
g/Nm^3 (dry)	0.0256	0.00938	0.00938	0.0181	0.0123
Gr/dscf	0.0112	0.0041	0.0041	0.0079	0.0054
kg/Mg feed	--	0.0247	0.0228	0.0307	0.0261
Lb/ton feed	--	0.0494	0.0456	0.0614	0.0521

---

a. This test was discarded since only 1/2 of the traverse was run because one of the predryers was shut down.

b. This test had a low gas flow rate, and low velocity head readings.

c. This average includes only tests 2,3, and 4.

TABLE C-19. PLANT C: SUMMARY OF EMISSION TEST RESULTS

Bleacher-Inlet to Cyclone/Electrostatic Precipitator

Test No.	1	2	3	Average
General Data		Cyclone Inlet No.1		
Date	7/16/79	7/17/79	7/18/79	--
Time	1750	1150	0815	--
Isokinetic ratio (%)	98.7	102.3	98.9	100
Gas Data				
Temperature (°C)	176	174	171	173
Temperature (°F)	348	345	340	344
Moisture (%)	4.6	6.1	4.4	5.03
Particulate Emissions				
g/Nm^3 (dry)	380	297	307	328
Gr/dscf	166	130	134	127
kg/Mg feed	228	161	185	191
Lb/ton feed	455	321	369	382

TABLE C-20. PLANT C: SUMMARY OF EMISSION TEST RESULTS

Bleacher-Inlet to Cyclone/Electrostatic Precipitator

Test No.	1[a]	2	3	Average[b]
General Data	Cyclone Inlet No.2			
Date	7/16/79	7/17/79	7/18/79	--
Time Started	1750	1115	0755	--
Isokinetic ratio (%)	104.0	104.4	111.9	108
Gas Data				
Temperature (°C)	217	180	172	176
Temperature (°F)	423	356	341	349
Moisture (%)	0.5	7.3	4.4	5.85
Particulate Emissions				
g/Nm^3 (dry)	--	277	104	191
Gr/dscf	--	121	45.6	83.3
kg/Mg feed	--	152	53	103
Lb/ton feed	--	303	106	205

---

a. This test was discarded because a leak developed in the sampling train during the test.

b. This average includes only tests 2 and 3.

TABLE C-21. PLANT C: SUMMARY OF EMISSION TEST RESULTS

Bleacher-Outlet from Cyclone/Electrostatic Precipitator

Test No.	1	2	3	Average
General Data				
Date	7/16/79	7/17/79	7/18/79	--
Time	1738	1102	0744	--
Isokinetic ratio (%)	99.4	94.1	98.1	97.2
Gas Data				
Temperature (°C)	106	83.9	78.3	89.4
Temperature (°F)	222	183	173	193
Moisture (%)	3.2	2.4	2.4	2.67
Particulate Emissions				
g/Nm^3 (dry)	0.0233	0.0124	0.00892	0.0149
Gr/dscf	0.0102	0.0054	0.0039	0.0182
kg/Mg feed	0.0306	0.0192	0.0121	0.0206
Lb/ton feed	0.0611	0.0384	0.0241	0.0412

TABLE C-22. PLANT C: SUMMARY OF OPACITY OPERATIONS

Predryer-Cyclone/Venturi Scrubber

Date	Time	6-minute interval	Average opacity %
7/19/79	1100-1123	1	0
		2	0
		3	0
		4	0
		5	-
		6	-
		7	-
		8	-
		9	-
		10	-
	1710-1750	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	-
		9	-
		10	-

TABLE C-22 (Cont.) SUMMARY OF OPACITY OBSERVATIONS

Predryer-Cyclone/Venturi Scrubber

Date	Time	6-minute interval	Average opacity %
7/20/79	1215-1315	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	1315-1415	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-22 (Cont.) SUMMARY OF OPACITY OBSERVATIONS

Predryer-Cyclone/Venturi Scrubber

Date	Time	6-minute interval	Average opacity %
7/21/79	0930-1030	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	1100-1200	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-23. PLANT C: SUMMARY OF OPACITY OBSERVATIONS

Bleacher-Cyclone/Electrostatic Precipitator

Date	Time	6-minute interval	Average opacity %
7/16/79	1740-1840	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	1840-1940	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-23 (Cont.) SUMMARY OF OPACITY OBSERVATIONS

Bleacher-Cyclone/Electrostatic Precipitator

Date	Time	6-minute interval	Average opacity %
7/17/79	1100-1156	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	1640-1715	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	-
		8	-
		9	-
		10	-

TABLE C-23 (Cont.) SUMMARY OF OPACITY OBSERVATIONS

Bleacher-Cyclone/Electrostatic Precipitator

Date	Time	6-minute interval	Average opacity %
7/18/79	0800-0900	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0
	0900-1000	1	0
		2	0
		3	0
		4	0
		5	0
		6	0
		7	0
		8	0
		9	0
		10	0

TABLE C-24. PLANT A: SUMMARY OF INDUSTRY EMISSION TEST RESULTS, COAL-FIRED CALCINER OUTLET FROM CYCLONE/ESP

Test no.	One	Two	Three	Average
General Data				
Date	9/14/78	9/14/78	9/15/78	
Time	1030-1140	1340-1455	0920-1025	
Isokinetic ratio (%)	99.95	101.1	102.5	101.2
Gas Data				
Temperature (C°)	227	231	231	229
Temperature (F°)	440	447	448	445
Moisture (%)	16.0	16.5	18.0	16.8
Particulate Emissions				
g/Nm^3 (dry)	0.0334	0.0069	0.0043	0.0149
gr/dscf	0.0146	0.0030	0.0019	0.0065
kg/Mg feed	0.070	0.0134	0.0091	0.0308
lb/ton feed	0.140	0.0268	0.0182	0.0617

TABLE C-25. PLANT A: SUMMARY OF INDUSTRY EMISSION TEST RESULTS, COAL-FIRED CALCINER OUTLET FROM CYCLONE/ESP

Test no.	One	Two	Three	Average
General Data				
Date	10/19/78	10/20/78	10/20/78	
Time	1035-1150	0910-1025	1305-1425	
Isokinetic ratio (%)	105.0	100.0	101.5	102.2
Gas Data				
Temperature (C°)	211	202	206	206
Temperature (F°)	412	395	403	403
Moisture (%)	8.52	12.9	14.2	11.9
Particulate Emissions				
g/Nm^3 (dry)	0.0062	0.0092	0.0027	0.0059
gr/dscf	0.0027	0.0040	0.0012	0.0026
kg/Mg feed	0.0134	0.0220	0.0061	0.0138
lb/ton feed	0.0268	0.0441	0.0123	0.0277

TABLE C-26. PLANT A: SUMMARY OF INDUSTRY EMISSION TEST RESULTS, COAL-FIRED CALCINER OUTLET FROM CYCLONE/ESP

Test no.	One	Two	Three	Average
General Data				
Date	6/20/77	6/21/77	6/21/77	
Time	1000-1210	1020-1235	1255-1505	
Isokinetic ratio (%)	99.8	99.0	99.5	99.4
Gas Data				
Temperature (C°)	224	216	216	218
Temperature (F°)	435	420	420	425
Moisture (%)	18.1	17.6	18.1	17.9
Particulate Emissions				
g/Nm^3 (dry)	0.0261	0.0117	0.0186	0.0188
gr/dscf	0.0114	0.00511	0.00812	0.00821
kg/Mg feed	0.0426	0.0200	0.0303	0.0310
lb/ton feed	0.0852	0.0400	0.0606	0.0619

TABLE C-27. PLANT A: SUMMARY OF INDUSTRY EMISSION TEST RESULTS, COAL-FIRED CALCINER OUTLET FROM CYCLONE/ESP

Test No.	One	Two	Three	Average
General Data				
Date	6/14/77	6/14/77	6/15/77	
Time	1020-1240	1310-1725	1000-1210	
Isokinetic ratio (%)	107.5	107.3	101.7	105.5
Gas Data				
Temperature (C°)	228	225	226	226
Temperature (F°)	443	437	438	439
Moisture (%)	16.9	17.1	17.3	17.1
Particulate Emissions				
g/Nm^3 (dry)	0.0705	0.0323	0.0181	0.0403
gr/dscf	0.0308	0.0141	0.00791	0.0176
kg/Mg feed	0.127	0.0575	0.0319	0.072
lb/ton feed	0.253	0.115	0.0638	0.144

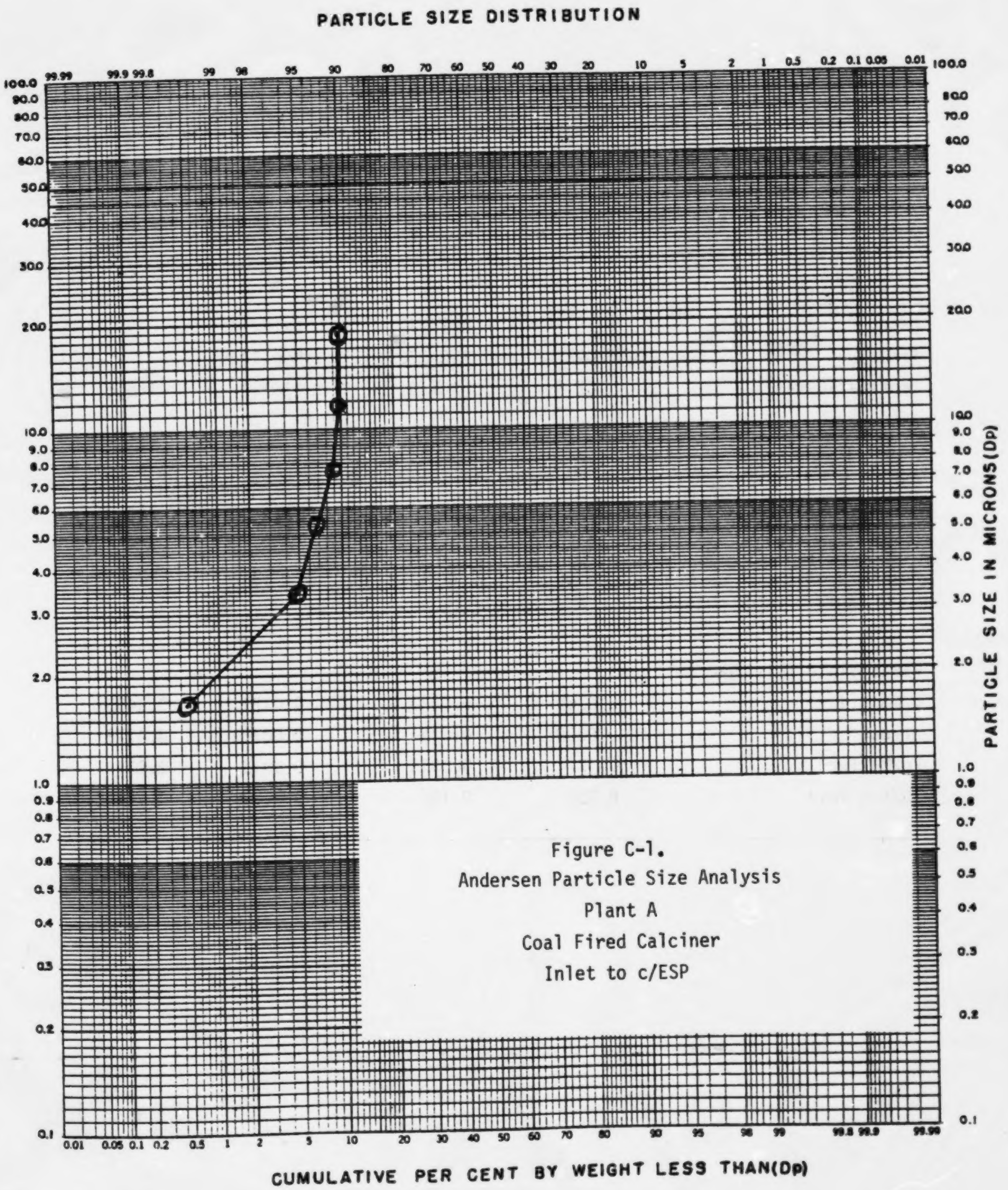

Figure C-1.
Andersen Particle Size Analysis
Plant A
Coal Fired Calciner
Inlet to c/ESP

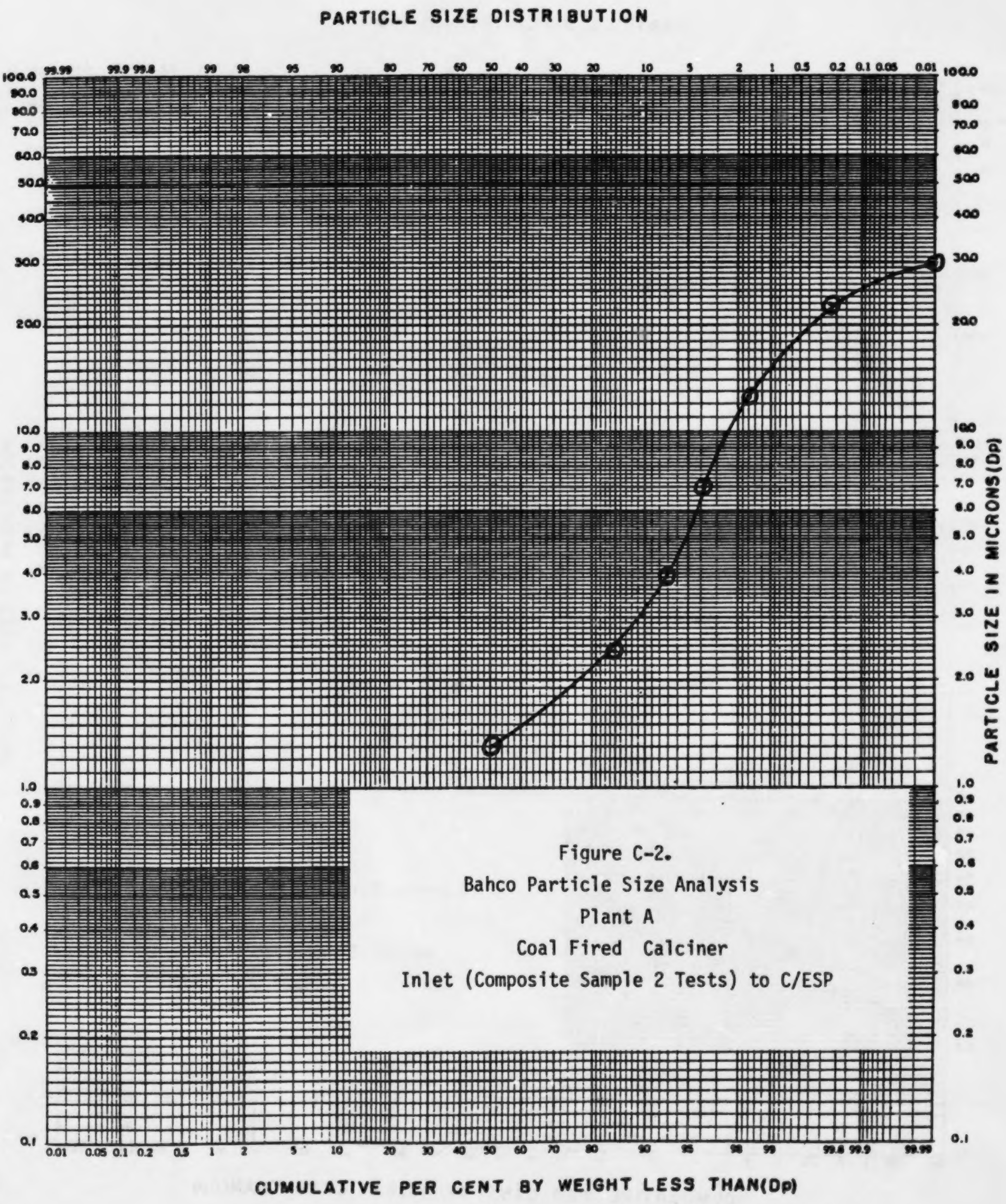

Figure C-2.
Bahco Particle Size Analysis
Plant A
Coal Fired Calciner
Inlet (Composite Sample 2 Tests) to C/ESP

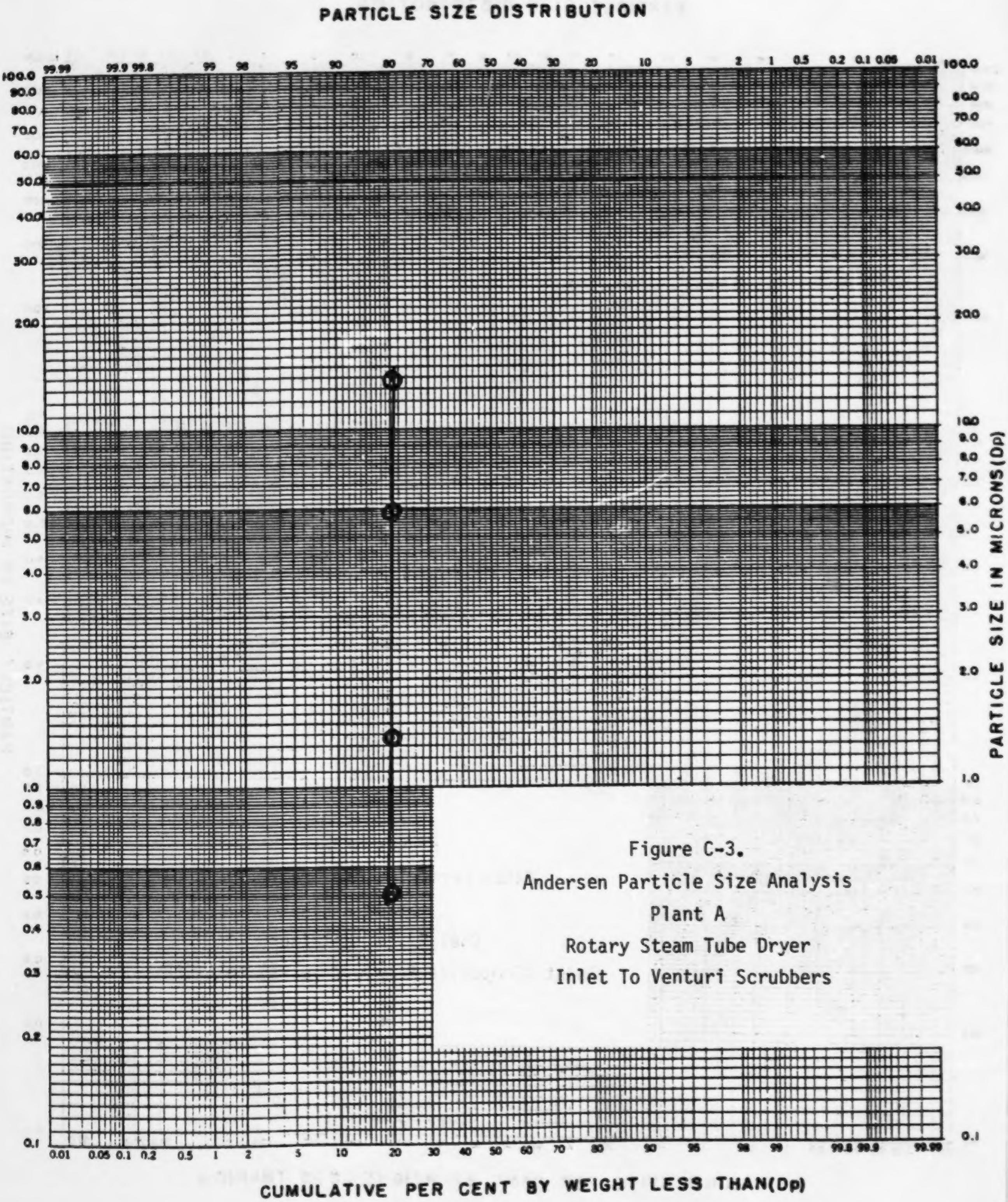

Figure C-3.
Andersen Particle Size Analysis
Plant A
Rotary Steam Tube Dryer
Inlet To Venturi Scrubbers

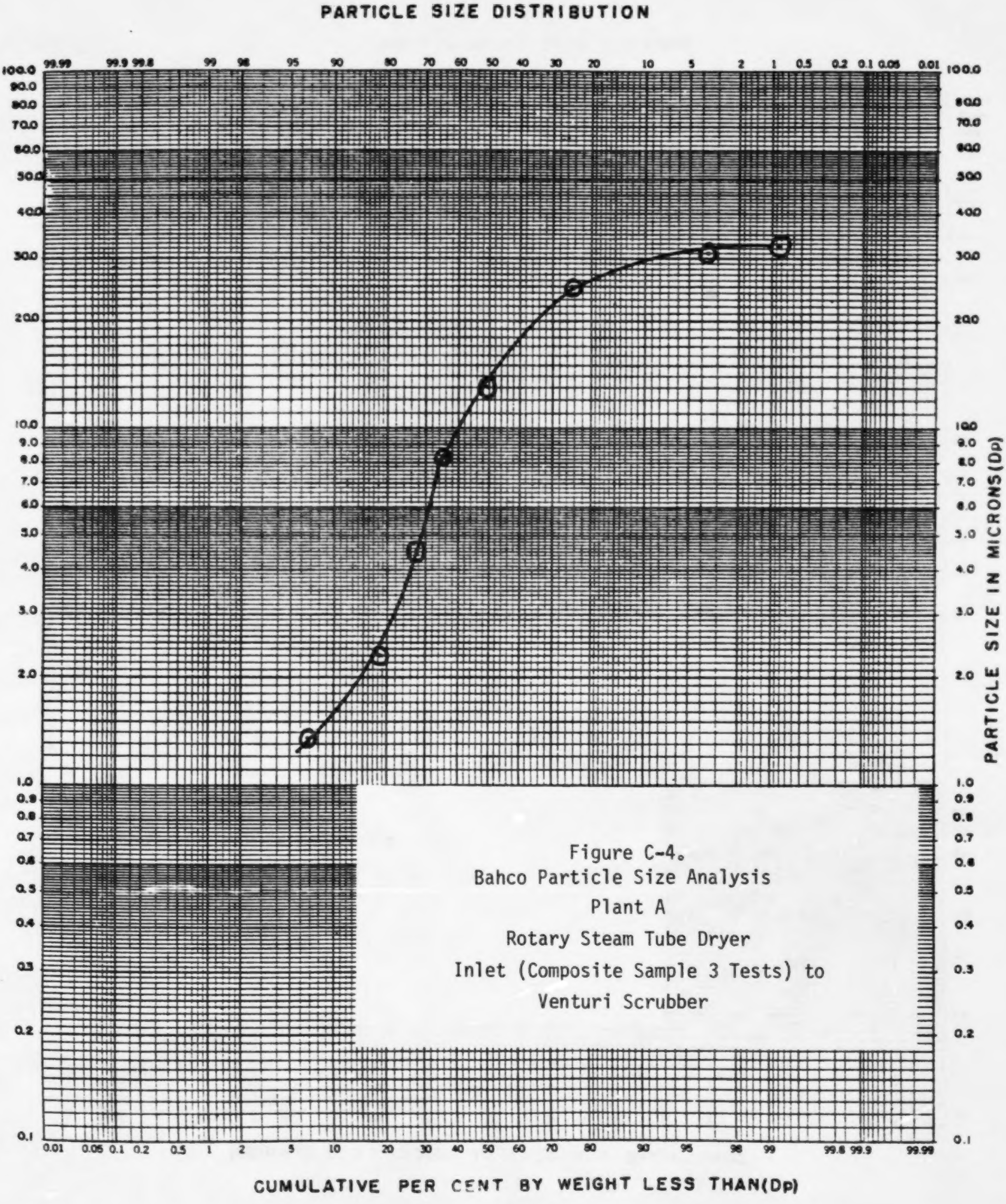

Figure C-4.
Bahco Particle Size Analysis
Plant A
Rotary Steam Tube Dryer
Inlet (Composite Sample 3 Tests) to
Venturi Scrubber

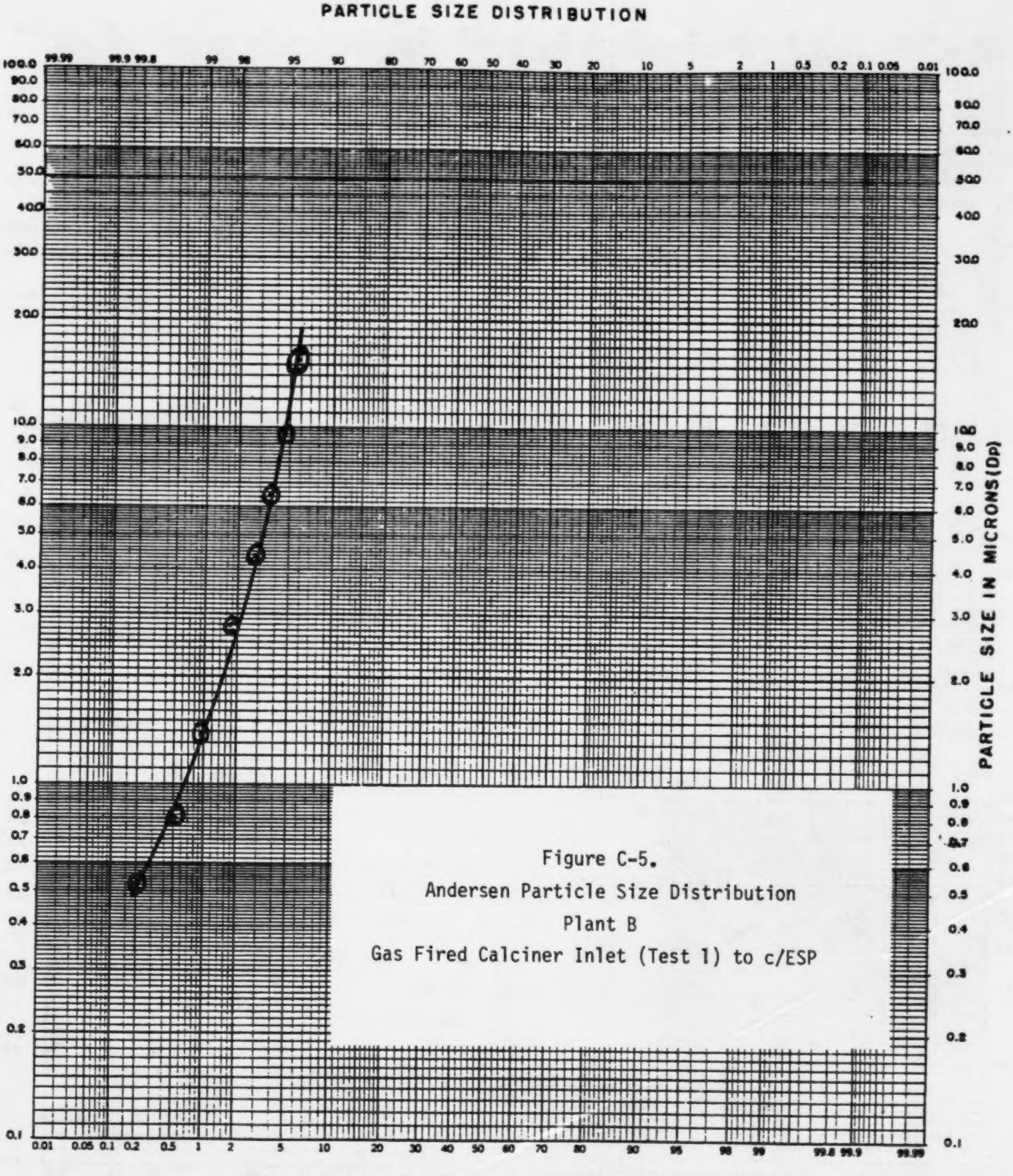

Figure C-5.
Andersen Particle Size Distribution
Plant B
Gas Fired Calciner Inlet (Test 1) to c/ESP

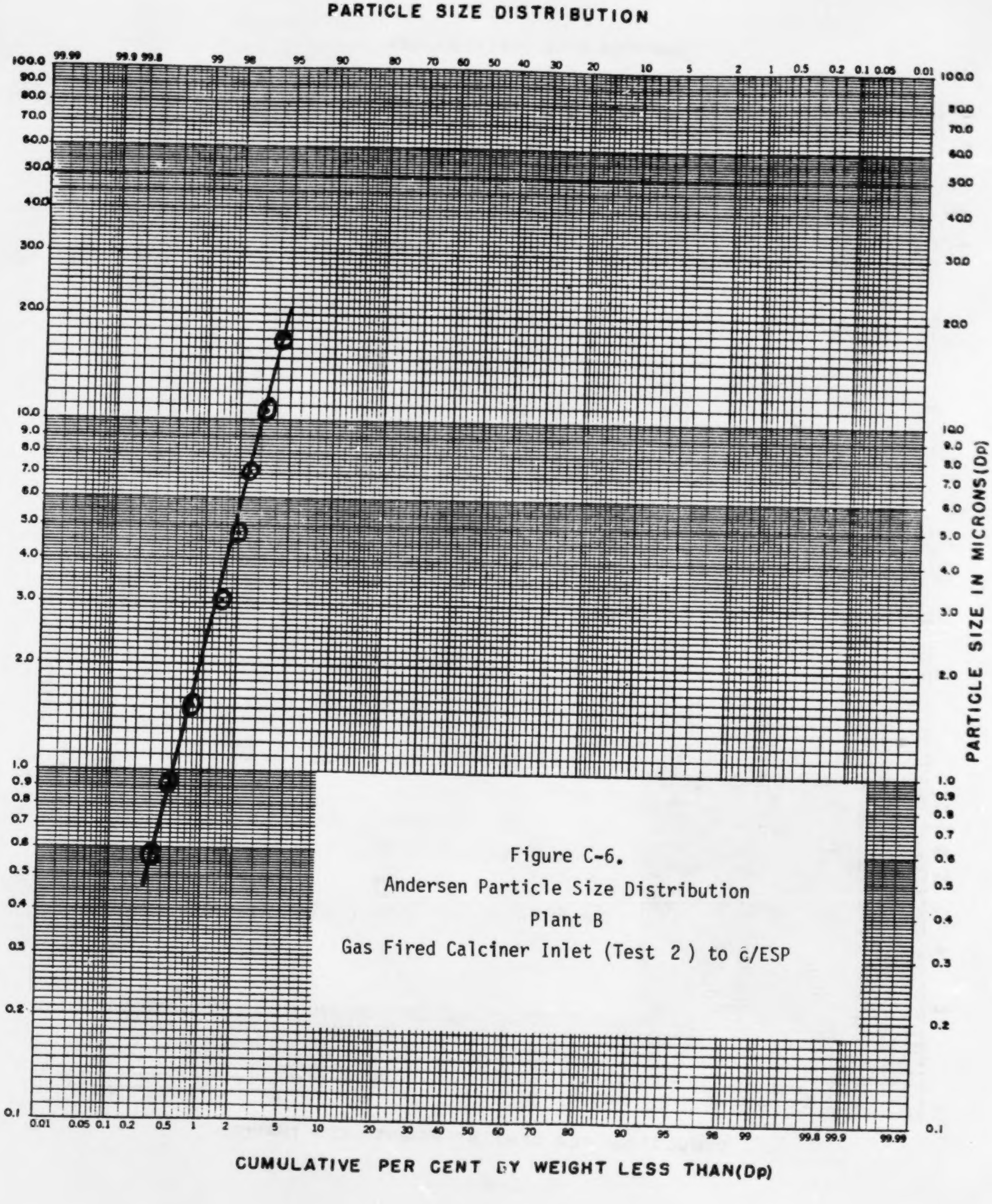

Figure C-6.
Andersen Particle Size Distribution
Plant B
Gas Fired Calciner Inlet (Test 2) to c̄/ESP

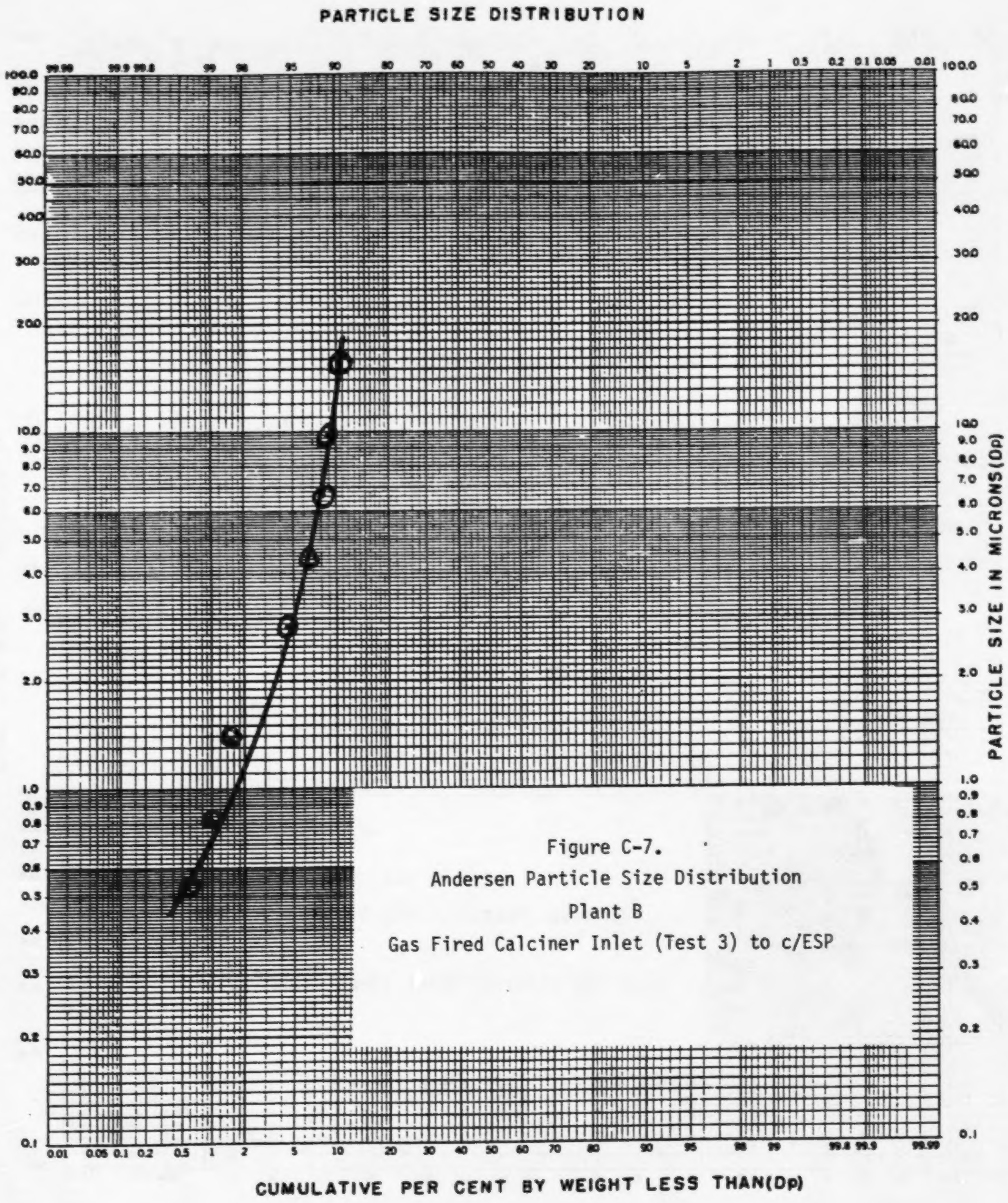

Figure C-7.
Andersen Particle Size Distribution
Plant B
Gas Fired Calciner Inlet (Test 3) to c/ESP

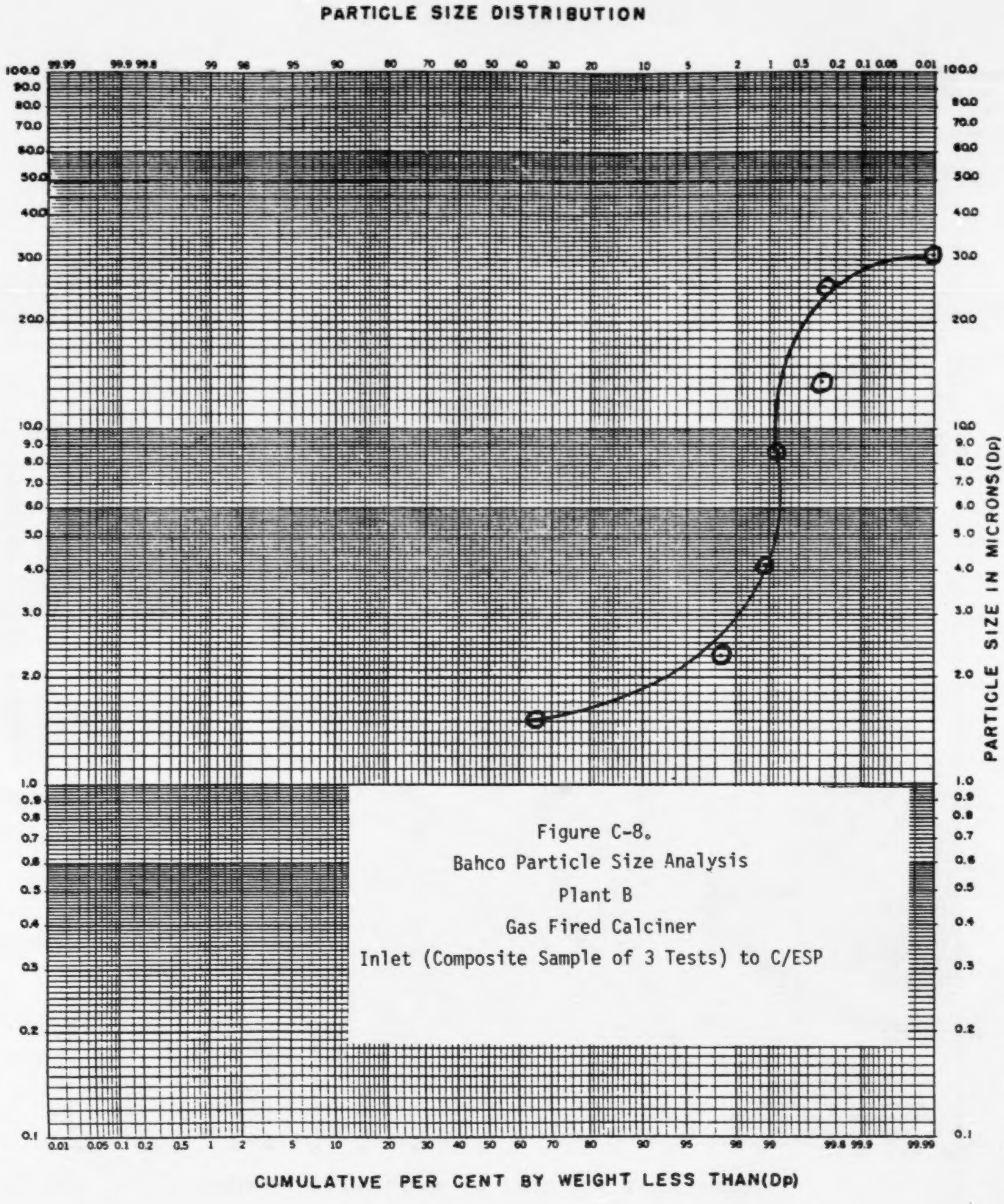

Figure C-8.
Bahco Particle Size Analysis
Plant B
Gas Fired Calciner
Inlet (Composite Sample of 3 Tests) to C/ESP

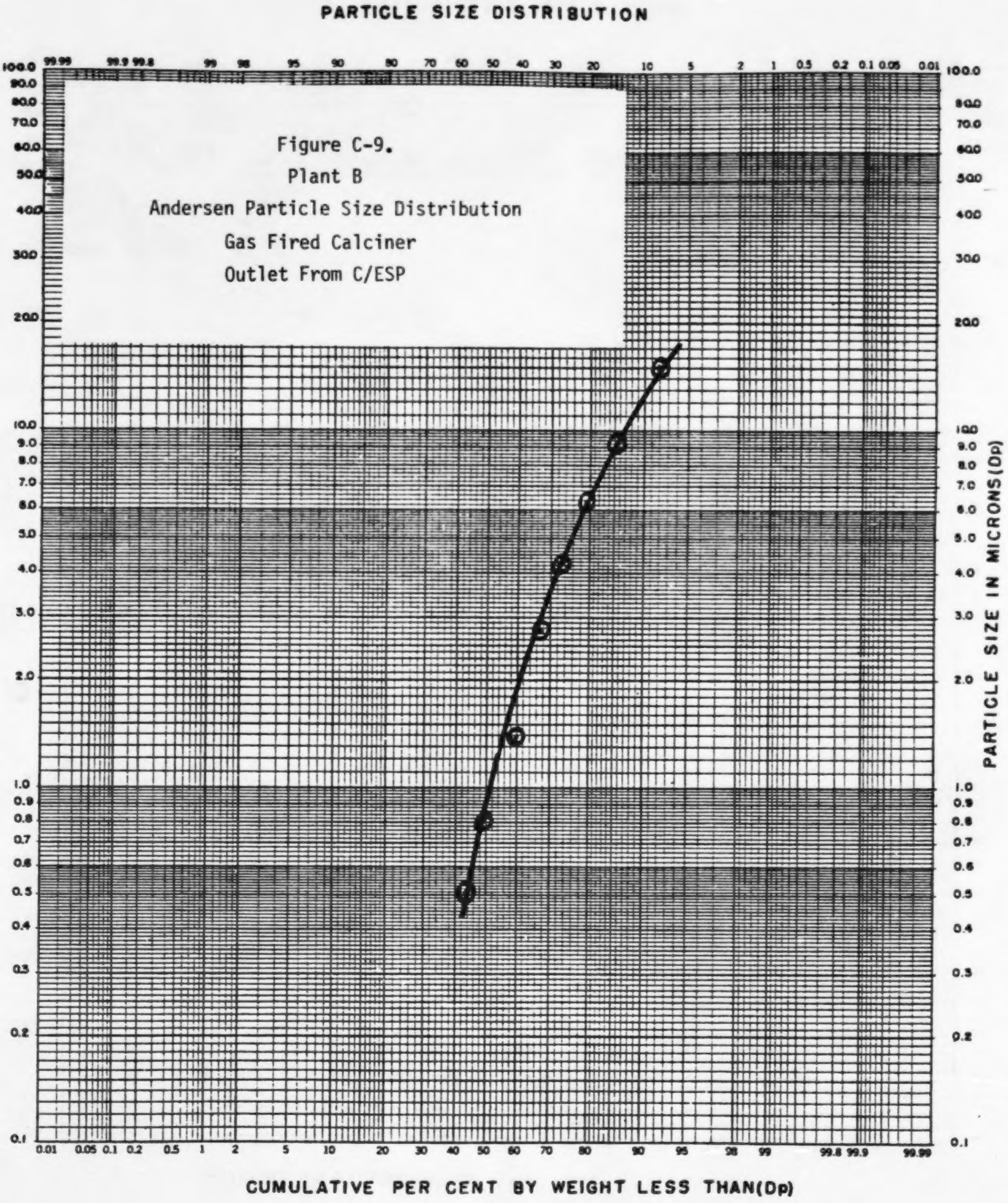

Figure C-9.
Plant B
Andersen Particle Size Distribution
Gas Fired Calciner
Outlet From C/ESP

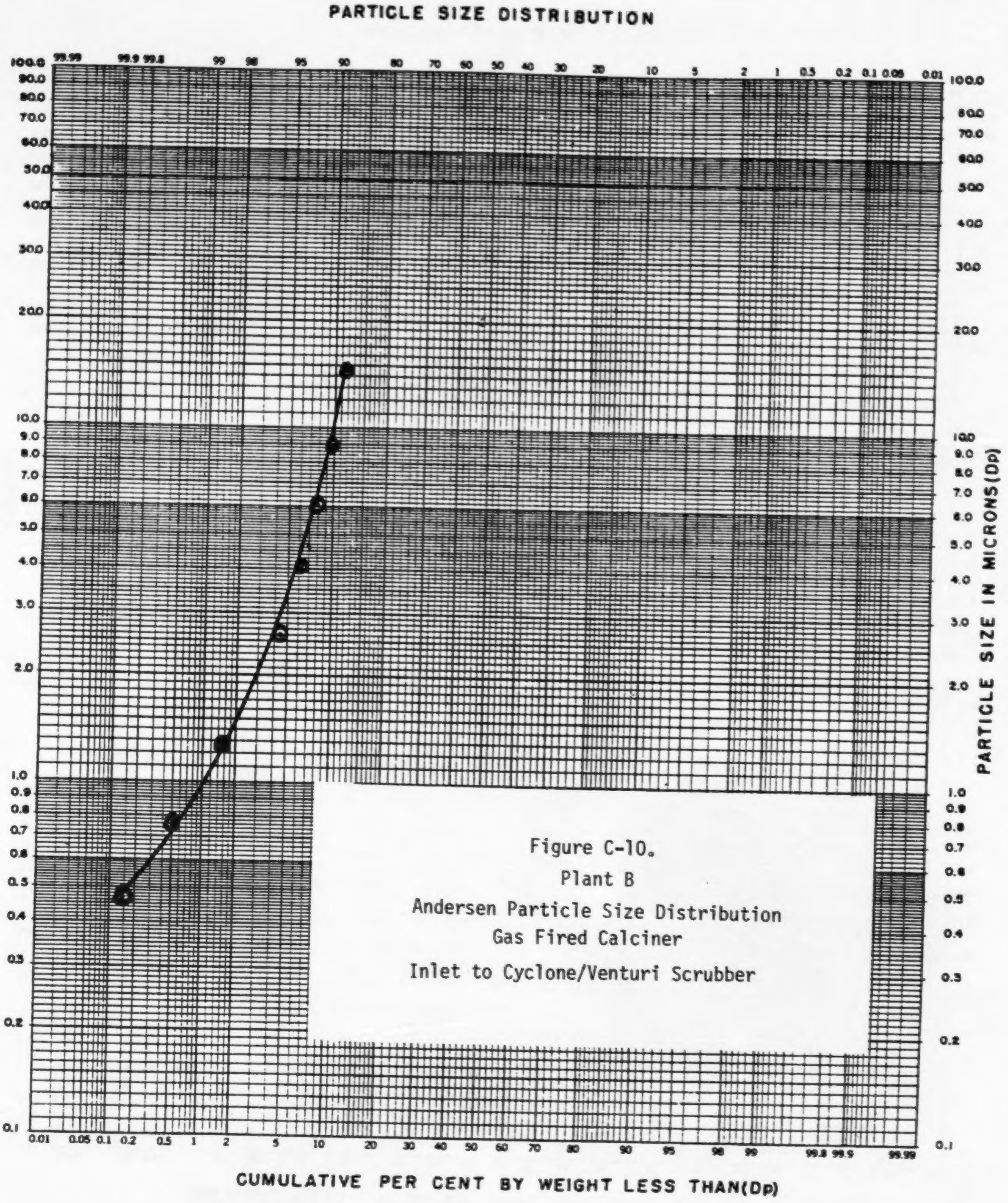

Figure C-10.

Plant B

Andersen Particle Size Distribution

Gas Fired Calciner

Inlet to Cyclone/Venturi Scrubber

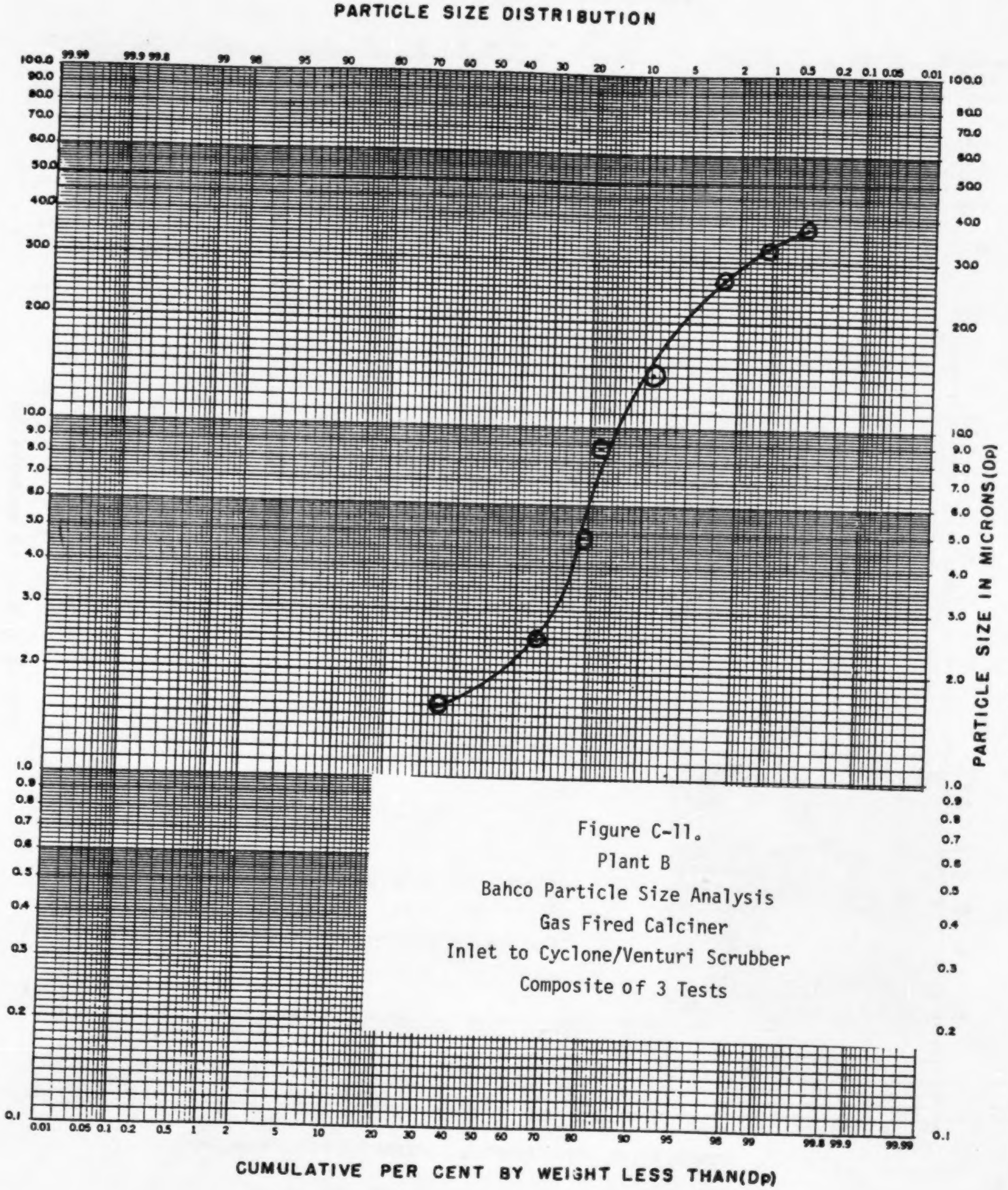

Figure C-11.
Plant B
Bahco Particle Size Analysis
Gas Fired Calciner
Inlet to Cyclone/Venturi Scrubber
Composite of 3 Tests

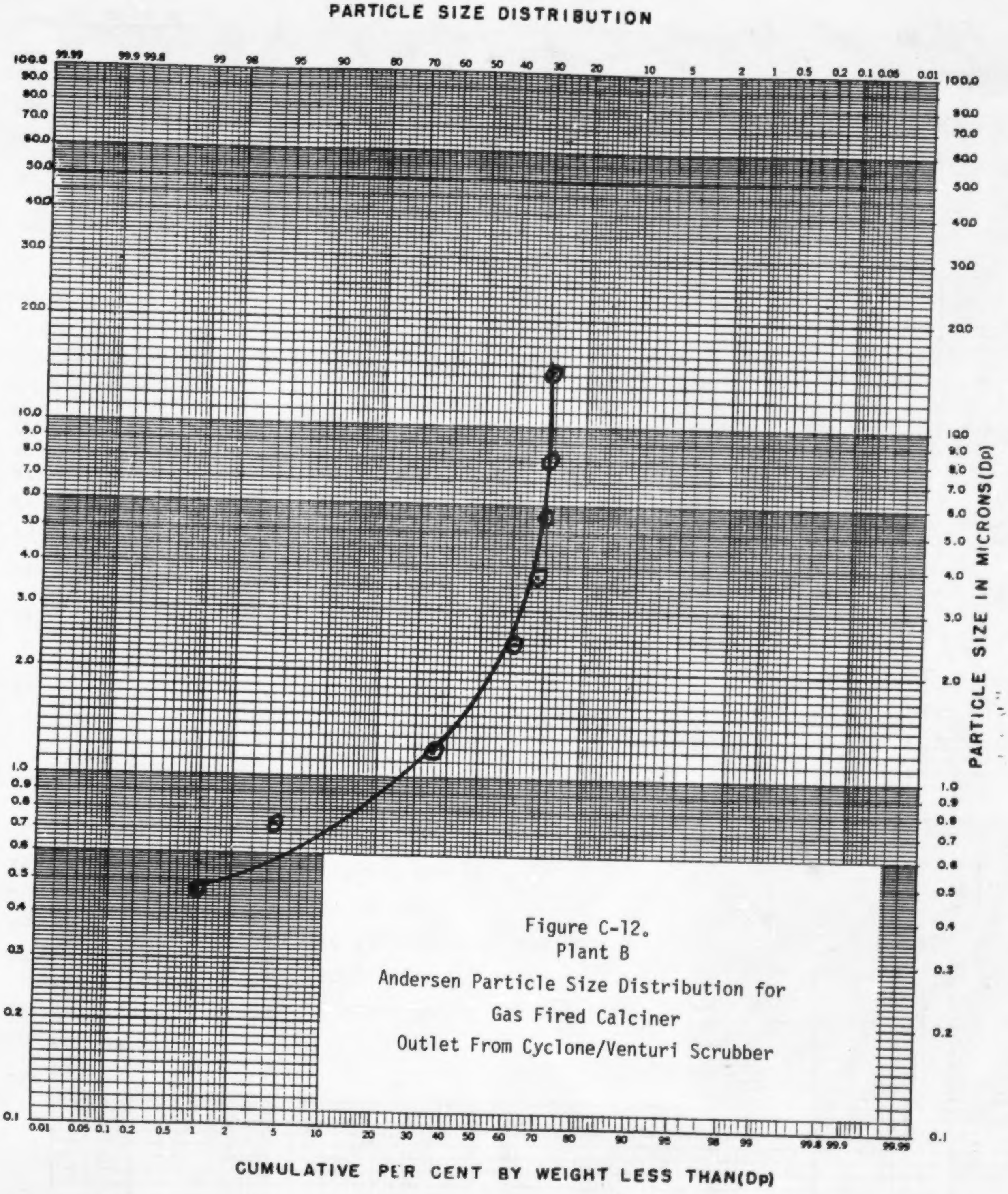

Figure C-12.
Plant B
Andersen Particle Size Distribution for
Gas Fired Calciner
Outlet From Cyclone/Venturi Scrubber

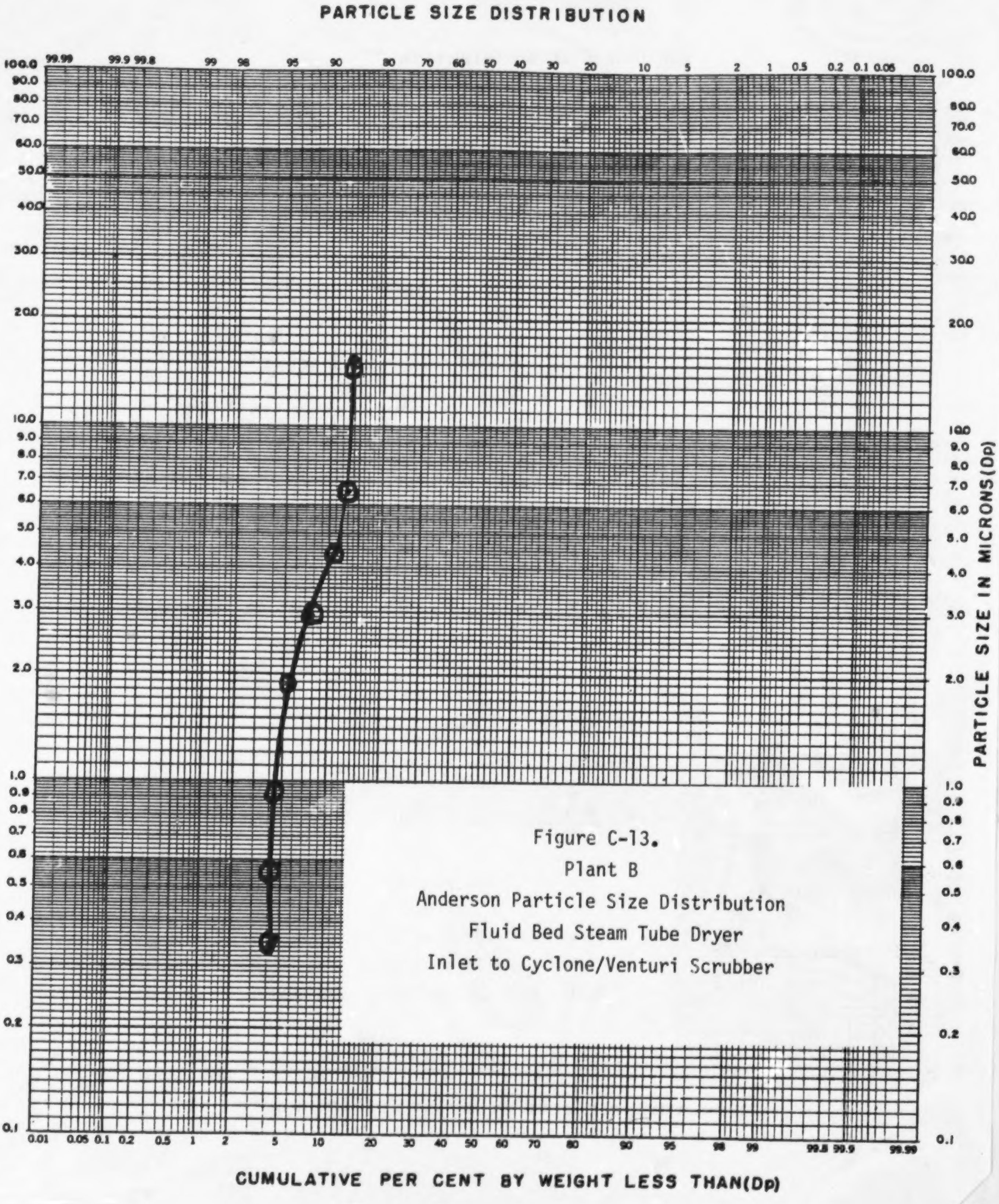

Figure C-13.

Plant B

Anderson Particle Size Distribution

Fluid Bed Steam Tube Dryer

Inlet to Cyclone/Venturi Scrubber

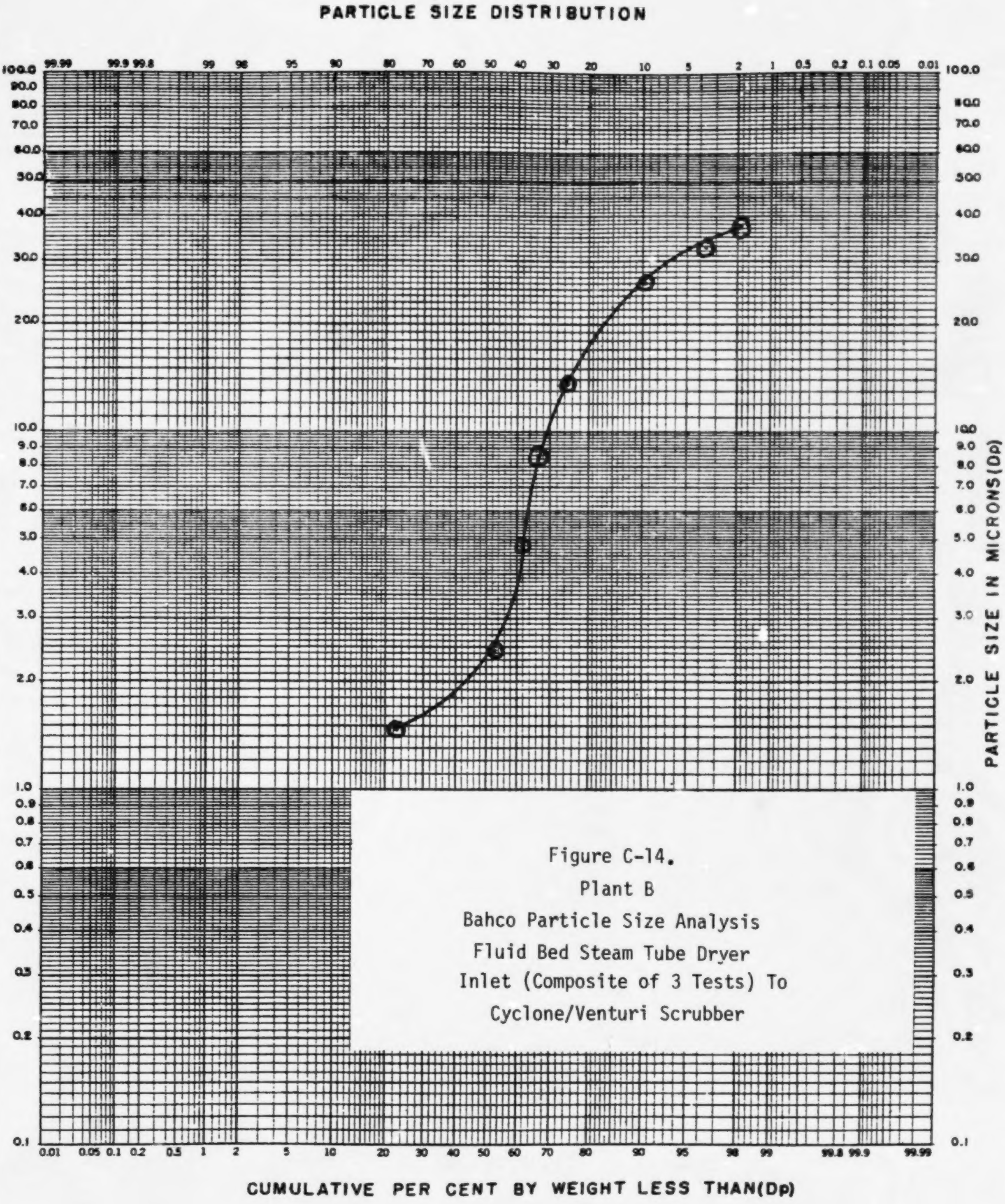

Figure C-14.

Plant B

Bahco Particle Size Analysis

Fluid Bed Steam Tube Dryer

Inlet (Composite of 3 Tests) To

Cyclone/Venturi Scrubber

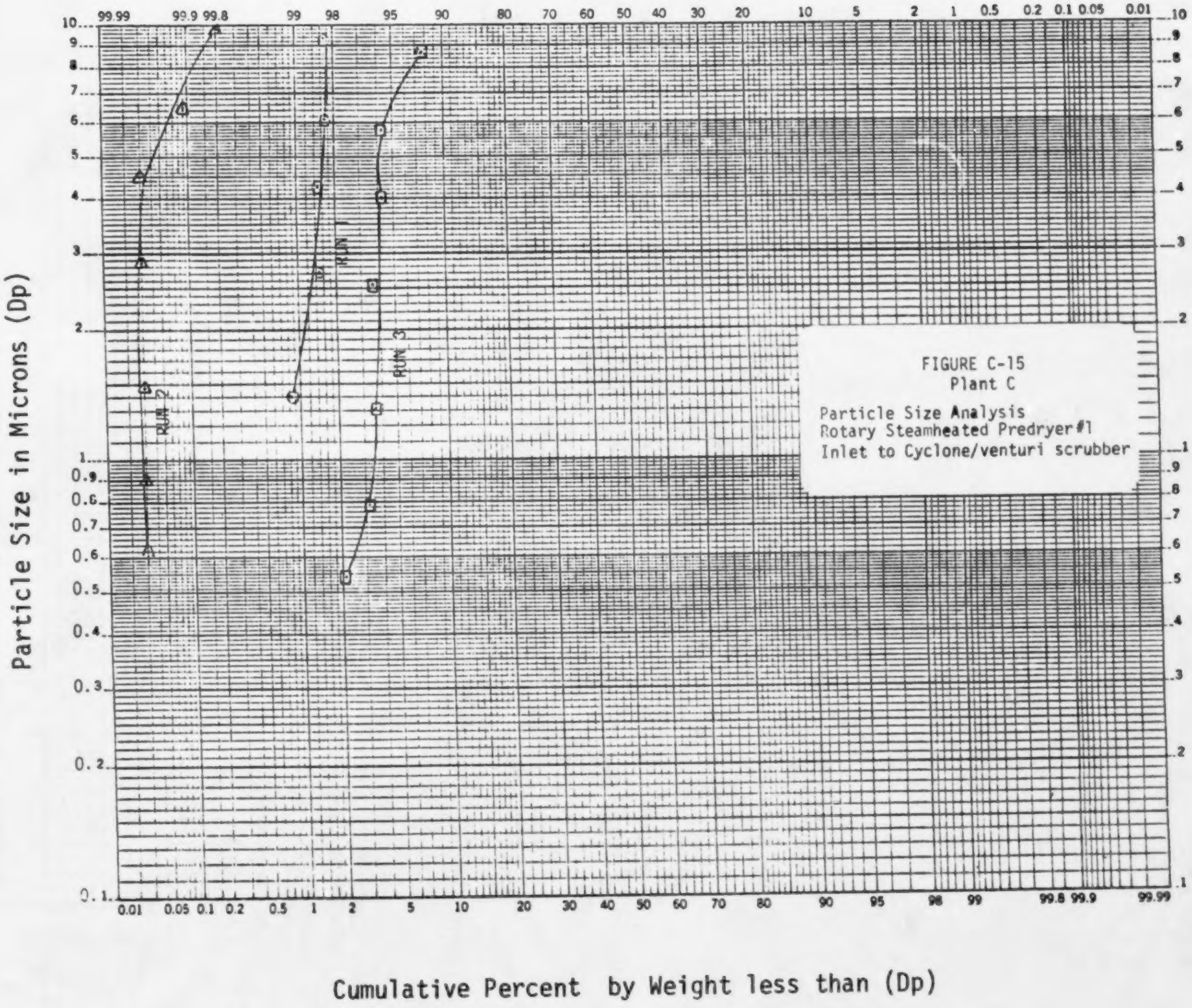

FIGURE C-15
Plant C

Particle Size Analysis
Rotary Steamheated Predryer#1
Inlet to Cyclone/venturi scrubber

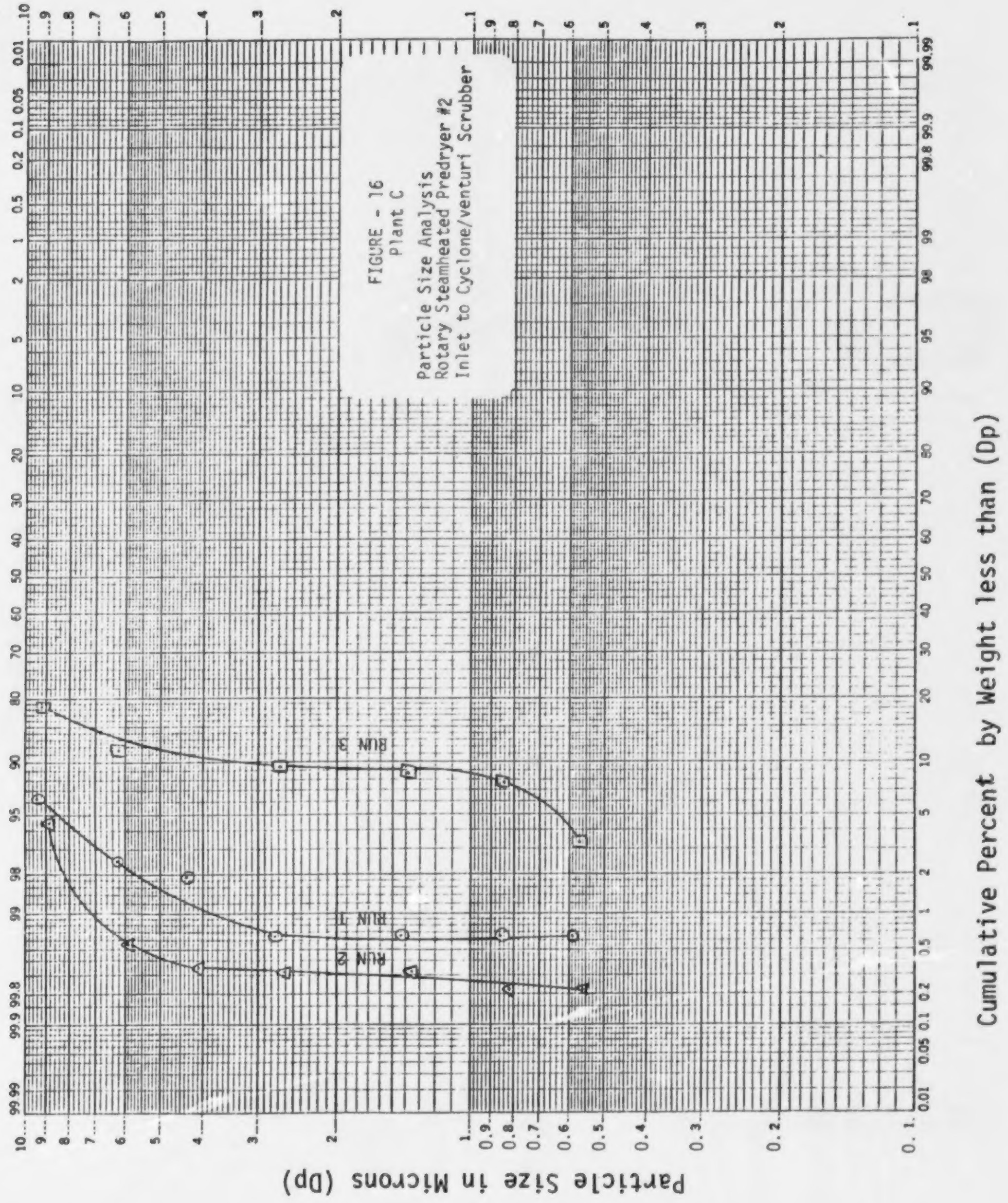

FIGURE - 16
Plant C

Particle Size Analysis
Rotary Steamheated Predryer #2
Inlet to Cyclone/venturi Scrubber

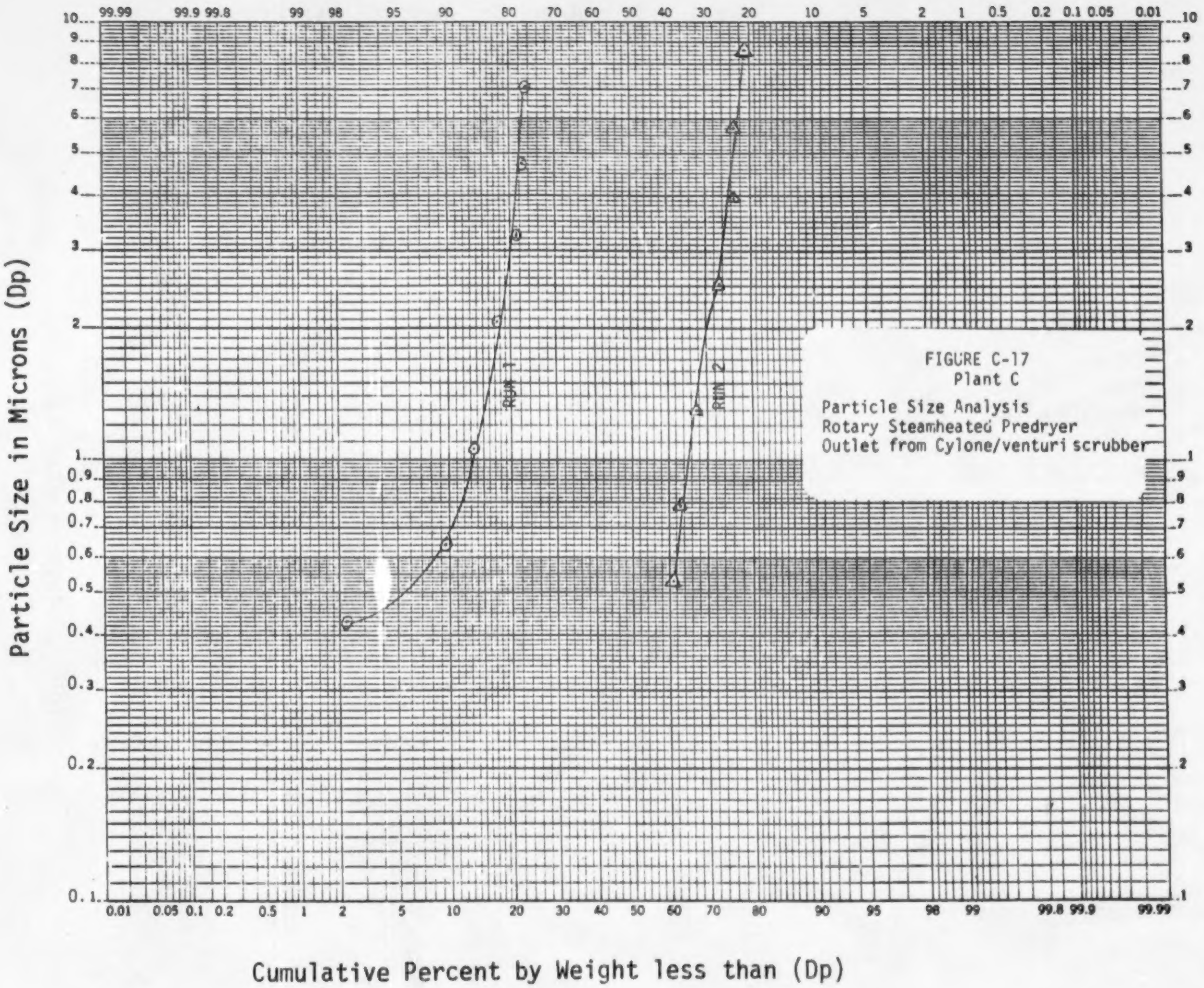

FIGURE C-17
Plant C

Particle Size Analysis
Rotary Steamheated Predryer
Outlet from Cylone/venturi scrubber

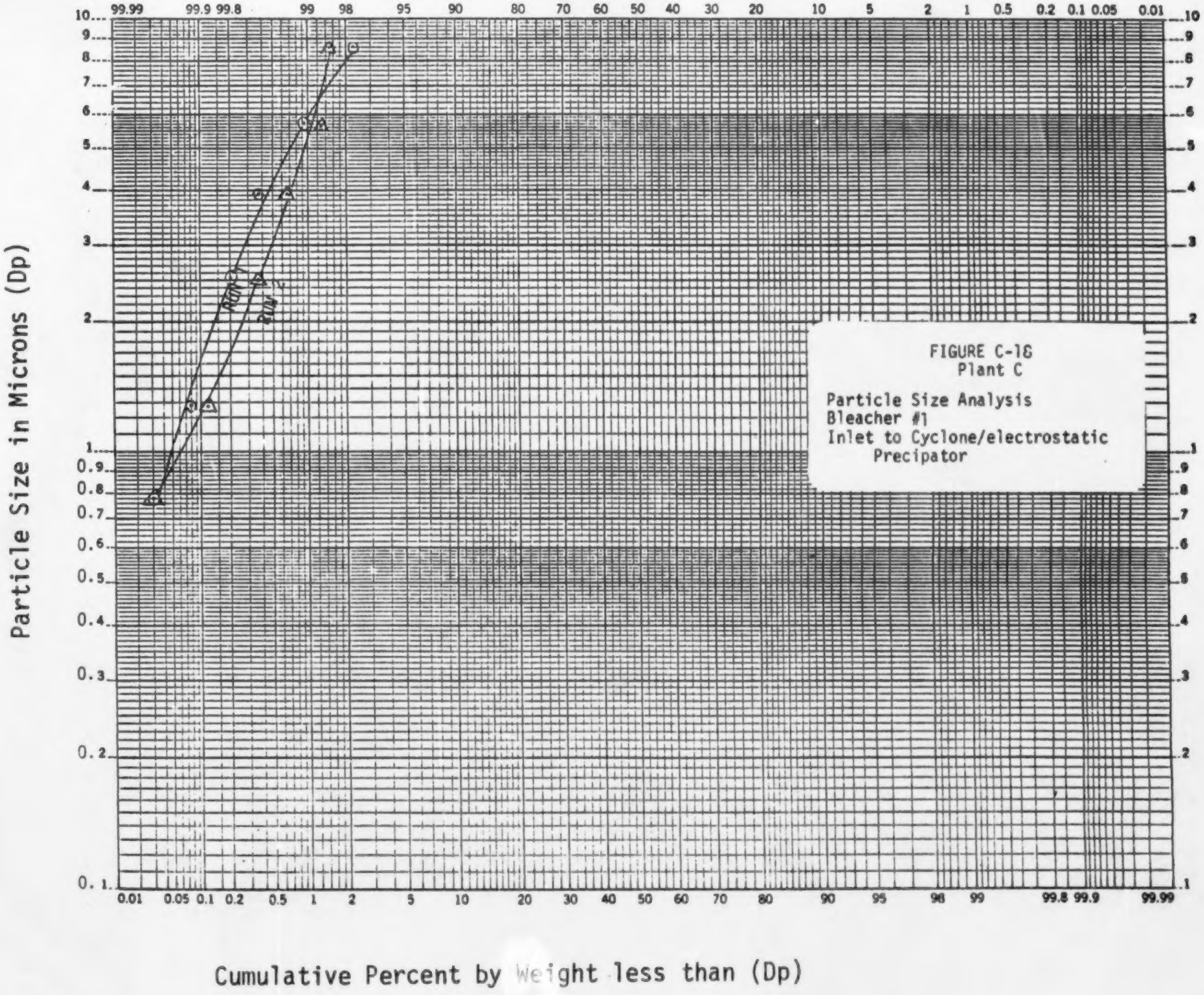

FIGURE C-18
Plant C

Particle Size Analysis
Bleacher #1
Inlet to Cyclone/electrostatic
Precipator

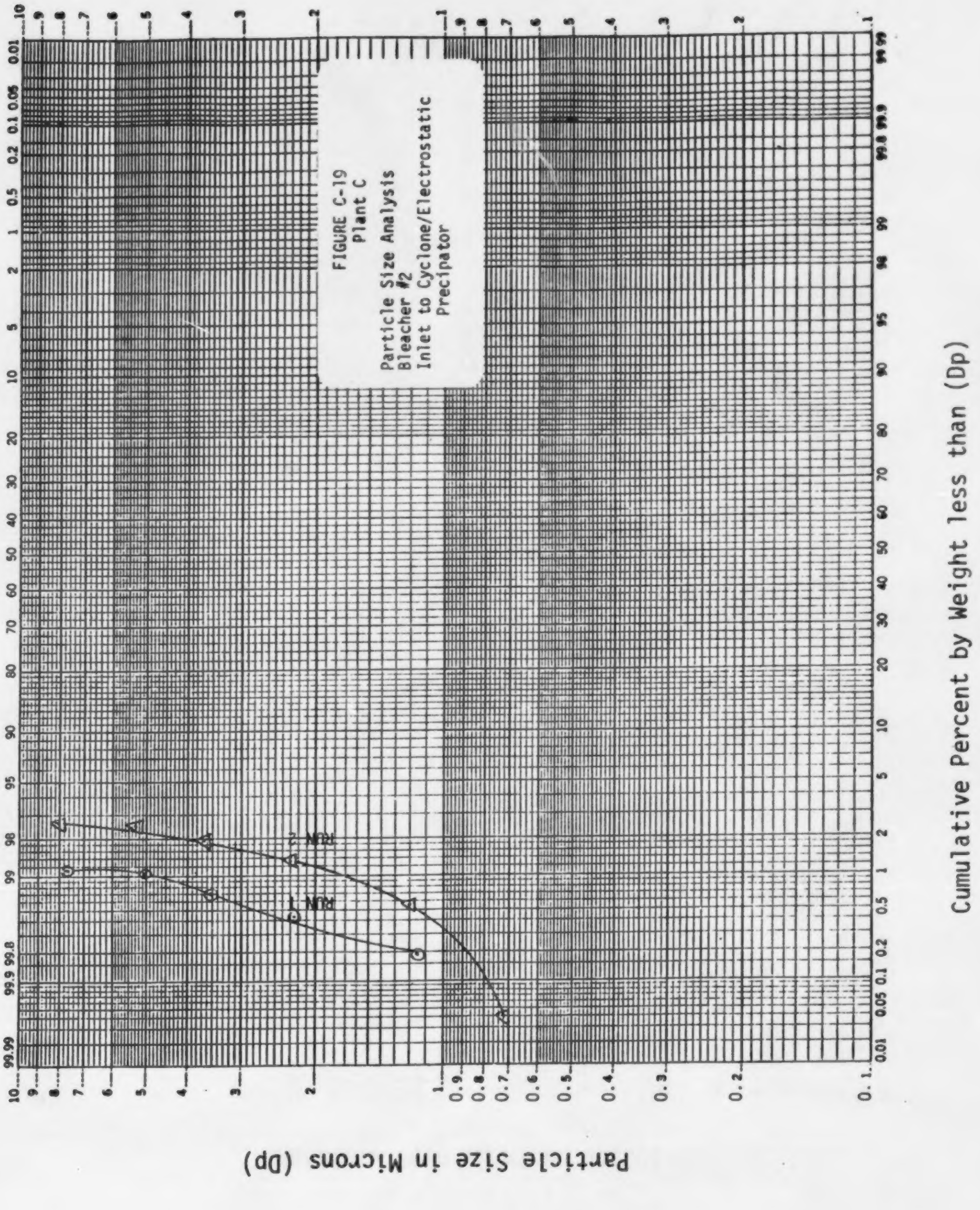

FIGURE C-19
Plant C
Particle Size Analysis
Bleacher #2
Inlet to Cyclone/Electrostatic
Precipator

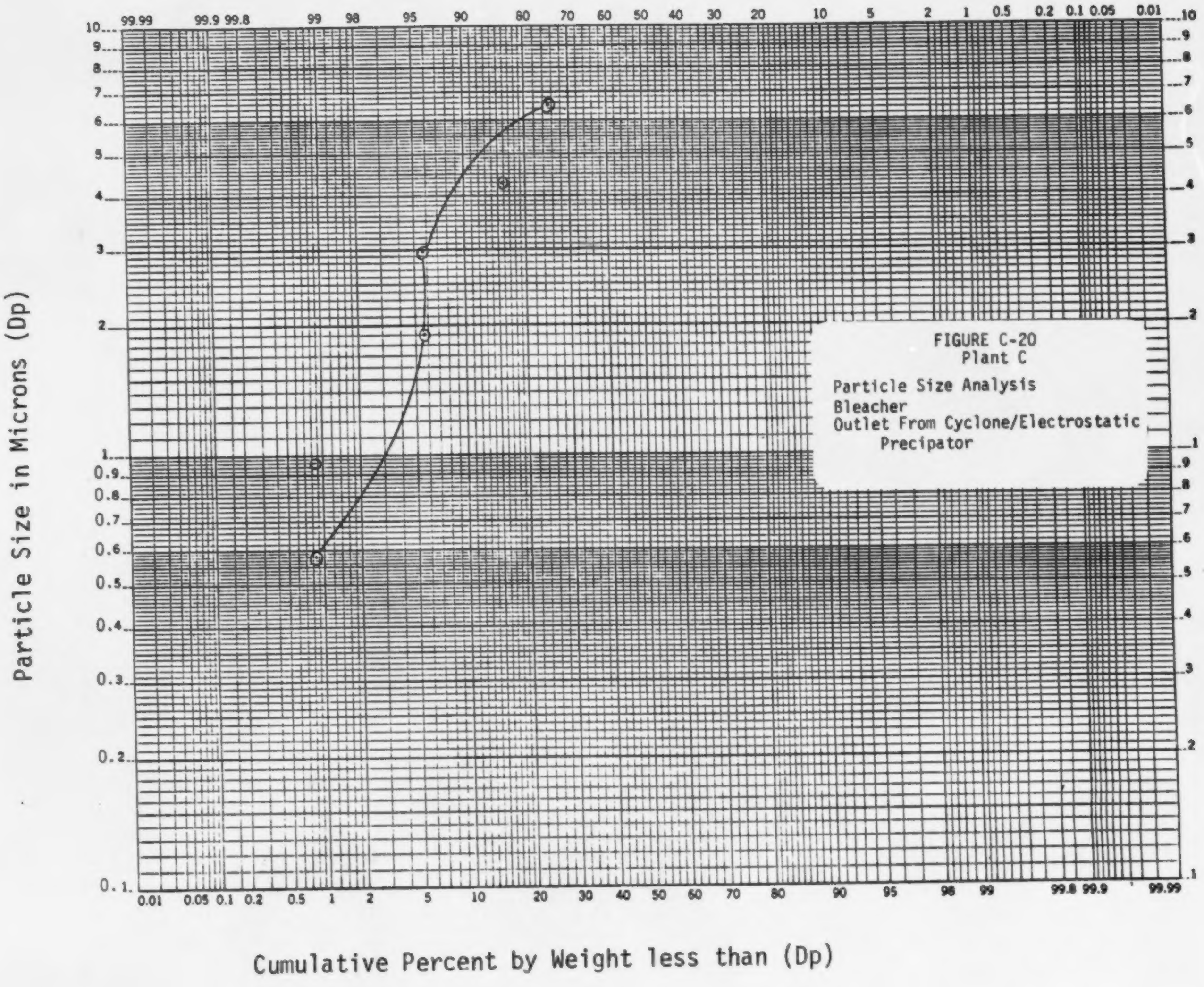

FIGURE C-20
Plant C

Particle Size Analysis
Bleacher
Outlet From Cyclone/Electrostatic
Precipator

APPENDIX D - EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 EMISSION MEASUREMENT METHODS

During the standard support test program for Sodium Carbonate Manufacturing plants, EPA conducted particulate emissions tests at three facilities controlled with scrubbers and combinations of cyclones and electrostatic precipatators. Three tests were run before and after the control device in accordance with EPA Method 5 (40 CFR Part 60 - Appendix A). Method 5 provides detailed procedures and equipment criteria, and other considerations necessary to obtain accurate and representative particulate emission data. In addition, sulfur oxide emissions were determined in accordance with EPA Method 6 (40 CFR Part 60 - Appendix A) and two of the plants were sampled for organics. The samples were analyzed by an AID model 621 portable Gas Chromatograph (GC) directly from a heated grab sampling flask. Visible emission data were taken during the three EPA tests in accordance with Method 9 (40 CFR Part 60 - Appendix A).

A few technical problems were encountered with the inlet testing to control devices. These included high moisture, anisokinetic sampling at one location, and an incomplete final run due to a process upset. However, none of these problems were considered to cause significant errors in the data. All of the outlet testing met the requirements of Method 5.

D.2 MONITORING SYSTEMS

The opacity monitoring systems that are adequate for other stationary sources, such as steam generators, covered by performance specifications contained in Appendix B of 40 CFR Part 60 Federal Register, October 6, 1975 are also technically feasible for sodium carbonate manufacturing plants except where condensed moisture is present in the exhaust stream. When wet scrubbers are used for emission reductions from sodium carbonate plants, monitoring of opacity is not applicable; therefore, another parameter, such as pressure drop, would need to be monitored as an indicator of emission control.

Equipment and installation cost for visible emission monitoring are estimated to be about $18,000 to $20,000 per site. Annual operating cost which include the recording and reducing the data, are estimated at about $8,000 to $9,000 per site. Some savings in operating costs may be achieved if multiple systems are used at a given facility.

Equipment and installation cost for monitoring scrubber pressure drop and scrubbing fluid flow rate are estimated to be about $7500 per scrubber. Annual operating costs, including examining and filing the data, would be about $3300.

D.3 PERFORMANCE TEST METHODS

Consistent with the data base upon which the new source standards have been established, the recommended performance test method for particulate matter is Method 5 (Appendix A, 40 CFR 60 - Federal Register), (December 23, 1971 as amended August 18, 1977). In order to perform Method 5, Methods 1 through 4 must be used.

Subpart A of 40 CFR 60 requires that affected facilities which are subject to standards of performance for new stationary sources must be constructed so the sampling ports adequate for the performance test are provided. Platforms access and utilities necessary to perform testing at those ports must be provided.

Sampling cost for performing a test consisting of three Method 5 runs is estimated to range from $5,000 to $9,000. If in-plant personnel are used to conduct the test, the cost will be somewhat less.

The recommended performance test method for visible emission is Method 9 (Appendix A, 40 CFR 60, Federal Register, November 12, 1974).

APPENDIX E. ENFORCEMENT ASPECTS

The recommended standards of performance will limit the emission of particulates from affected facilities at new or modified sodium carbonate production plants. The affected facilities are calciners, dryers, predryers, and bleachers. The standard will be defined as a mass emission limitation in conjunction with a visible emission limitation. Compliance with these standards can be achieved by installation of a dry collection system (cyclone/electrostatic precipitator) or a wet scrubbing system (venturi scrubber with or without a cyclone). Emissions from each facility will be treated by a separate control system. Aspects of enforcing these standards of performance are discussed below.

E.1 PROCESS OPERATION

To ensure normal operation during enforcement testing the calciner, bleacher, and dryer (including predryer) process weight rates should be monitored. These parameters should be determined by direct measurement or calculated using material balances based on sound engineering methods. The standards will require the installation of belt scales at the proper locations to measure feed or production rates unless the producer can present an accurate method for indirectly calculating these rates.

For example, the production rate of the dryer can be calculated using a correlation between production rates and steam usage rate. This correlation may be based on prior production records, or detailed mass and energy balances on the dryer.

The following is a method used at an existing direct carbonation plant to calculate the predryer feed rate. Modifications may be necessary if it is to be applied successfully at other direct carbonation plants.

Raw data required -

A = Alkalinity of the brine feed to the carbonators

B = Alkalinity of the supernatant liquor off the slurry from the bicarbonate crystallizers

C = Density of the filtrate from the bicarbonate filters (lb/gal)

D = Filtrate flow rate (gpm)

E = % Impurity content of the feed on a dry basis

$$\begin{array}{l}\text{TPH of Feed} \\ \text{as pure } Na_2CO_3\end{array} = D \text{ X } [A-B] \text{ X } C \text{ X } 1.59 \text{ X } 10^{-4} \left(\frac{\text{Ton min}}{\text{lb hr}} \right)$$

$$\begin{array}{l}\text{TPH of Feed} \\ \text{as pure } NaHCO_3\end{array} = \begin{array}{l}\text{TPH of Feed} \\ \text{as pure } Na_2CO_3\end{array} \text{ X } 1.58 \left(\frac{\text{Ton } NaHCO_3}{\text{Ton } NA_2CO_3} \right)$$

$$\begin{array}{l}\text{TPH of Feed} \\ \text{as impure dry} \\ NaHCO_3\end{array} = \left[\begin{array}{l}\text{TPH of Feed} \\ \text{as pure } Na_2CO_3\end{array} \right] / [1-E]$$

The bleacher feed rate can be obtained by assuming that there is no loss of available Na_2CO_3 between the predryer feed point and the bleacher feed point, but that there is a process lag time which must be taken into consideration.

E.2 DETERMINATION OF COMPLIANCE WITH A MASS EMISSION STANDARD

EPA test method 5 (40 CFR 60) will be used to determine the particulate emissions from each affected facility. This test yields the concentration of particulates in the stack gas. Test methods 1 through 4 measure the stack gas volumetric flow rate and moisture content. These data, coupled with the process weights of the affected facilities, will be used to determine the emission rate on a unit of production basis.

The necessary process weight rates will be supplied by direct measurements or engineering calculations (see Section E.1). These rates include inlet feed rates to the calciner and bleacher and production rates of the dryer and predryer. If weight rates are determined by direct measurement, the belt scales must be properly calibrated before the test.

New facilities can and should be designed to ensure that the optimum sampling conditions exist, even though the test methods allow for some deviation from the desired conditions. As an example, for EPA test method 1 the optimum location for the sampling point is at a distance equal to 8 or more duct diameters downstream and 2 or more duct diameters upstream of any expansion, construction, or other element which might disturb the gas flow pattern.

E.3 DETERMINATION OF COMPLIANCE WITH A VISIBLE EMISSIONS STANDARD

The compliance testing of a visible emissions standard for particulate emissions requires only an observer trained in the reading of visible emissions. These tests can be performed with little preparation and require no advance notice to the producer. All visible emission measurements will be performed according to EPA test method 9 for stack emissions. When a scrubber is used this test method applies after the steam plume has dispersed.

A bluish haze has been observed at the exhaust of several calciners and may present a problem in the enforcement of the visible emission standard. It is suspected that this haze is caused by either organics or extremely fine particulates. Thus, enforcement of the opacity standard may not be appropriate during periods when the blue haze is visible. In addition, if this blue haze is found to impair compliance with the visible emission standard, the producer may petition the Administrator according to part 60 Section 113 to establish a new visible emission standard for that particular calciner.

E.4 EMISSION MONITORING REQUIREMENTS

The recommended standards of performance do not require the installation of a continuous particulate monitoring system. However, the use of continuous opacity monitors would ensure proper operation and maintenance of the electrostatic precipitators. The continuous use of a transducer and recorder to monitor the pressure drop of the venturi scrubber would ensure that the pressure drop required to meet the particulate standards is properly maintained.

APPENDIX F

REPORTS IMPACT ANALYSIS

Comprehensive reporting of emission data and control equipment operating parameters are necessary in order to ensure compliance with new source performance standards promulgated in accordance with Section 111 of the Clean Air Act. The reporting requirements and their impacts on industry and enforcement agencies are discussed in this appendix.

F.1 REPORTING REQUIREMENTS

The purposes for collecting and maintaining the data required by the proposed standards are to demonstrate compliance with the standards and to ensure the proper operation and maintenance of the emission control equipment. The proper operation and maintenance of the control equipment will ensure continued compliance with the proposed standards. A determination of the proper operation and maintenance of the control equipment can be made by continuously monitoring control equipment operating parameters or visible emissions. The enforcement branch of the EPA or the state governments can use the data provided by this monitoring to determine if an affected facility is properly operating and maintaining the control equipment.

The proposed standards will require reports for the following:

1) notification of construction
2) notification of anticipated start-up
3) notification of actual initial start-up
4) notification of physical or operational changes

In addition, a performance test to determine compliance and a demonstration of a continuous monitoring system will be required for each emission source. Reports giving notification prior to these tests and a report of the tests will be required. Excess emission reports will be required four times a year.

The operator will be required to maintain records of any start-ups, shut-downs, and malfunctions of the control equipment or the continuous monitoring system. A file of all measurements as described in Section 60.7(d) of the General Provisions must also be maintained.

The standards proposed apply only to affected facilities in the natural process sodium carbonate industry. It is anticipated that through the fifth year of applicability of the standard the following facilities will be affected:

- calciners (controlled by C/ESP)	2
- dryers (controlled by VS or C/VS)	3
- predryers (controlled by C/VS)	1
- bleachers (controlled by C/ESP)	1

A continuous opacity monitor will be required for facilities controlled by a cyclone/ESP or baghouse. A single monitor will be required for each stack associated with the source. The alternative of monitoring the operating parameters of the ESP would require the measurement of more parameters and thus more extensive bookkeeping.

For facilities controlled by a venturi scrubber a continuous monitoring of operating parameters will be required. Transducers and recorders will be used to constantly record the pressure drop across the venturi scrubber and the scrubber liquor supply. Two parameters would be recorded for each venturi scrubber. There is one scrubber per source.

F.2 IMPACT ANALYSIS

This section will discuss the cost and burden required by the respondent and the Enforcement Agency to collect, prepare, and use the data required to determine compliance with the standard. Impacts are expressed in terms of dollars and man-hours.

F.2.1 Respondent

The man-hours required to fulfill the reporting requirements are presented in Table F-1. These hours were estimated using government guidelines for non-mass produced sources. (The equipment is individually designed, not mass produced.) The calculations are based on a five year period and use the affected facilities discussed in Section F.1. It is anticipated that there will be seven affected facilities subject to the proposed standards in the five year projection. These facilities will be spread between either two or three respondents.

TABLE F-1. SUMMARY OF MANHOURS NECESSARY FOR THE RESPONDENTS TO COMPLETE REPORTING REQUIREMENTS

Type of Report	Hours/Report	Reports/Source	Number of Sources	Total Hours
Notification of Construction	2	1	7	14
Notification of Anticipated Start-up	2	1	7	14
Notification of Actual Initial Start-up	2	1	7	14
Notification of Physical or Operational Changes	-	none anticipated	-	0
Notification of Demonstration of the Continuous Monitoring System	2	1	7	14
Continuous Monitoring Demonstration[a]	8	1	3	24
	8	2	4	64
Maintenance of Records of Start-up, Shut-downs, Malfunctions, and Periods of Inoperation of the Control Equipment[b]	80	5	7	2800
Excess Emission Reports[c]	8	15	7	840
	40	5	7	1400
Maintenance of a file of all Measurements as described in Section 60.7(d) of the General Provisions[b]	80	5	7	2800
Notification of the Administrator Prior to a Performance Test[a]	2	1	3	6
	2	2	4	16
Performance Test Reports[a]	40	1	3	120
	40	2	4	320
TOTAL				8446

[a] It is assumed that 50 percent of the sources will submit one report, and that 50 percent will submit two reports.

[b] It is assumed that 80 manhours per year are required to maintain these records. This impact analysis is projected over 5 years. Thus, each year is considered as one report.

[c] Each source is required to submit four reports each year. It is assumed that three of these reports will report no excess emissions and will require 8 hours per report, and that one report will report excess emissions and will require 40 hours/report.

The total cost to all respondents after five years is approximately $92,900 (based on $11/man-hour). Each respondent would have a different number of sources. Assuming three respondents (two with two sources, one with three sources) the breakdown of expenses that would occur is presented in Table F-2.

The reporting requirements are small and would not significantly affect any of the respondents' planning or budgets. These reporting requirements will be reviewed four years from the date of promulgation. This revision process will include participation by affected parties and the general public.[1] At the end of the review period the reporting requirements will be either extended or discontinued.

F.2.2 Enforcement Agency

The same basis used to calculate the respondent's labor requirements and monetary expenditures are used to calculate the Agency's requirements. The man-hours needed to meet the reporting requirements are presented in Table F-3.

The total cost, in five years, to the Agency is approximately $9,420. The cost would be $384 for the first year of the requirements and $130 for each year afterwards.

The reporting requirements of the proposed standards are very small and would not significantly affect any of the Agency's record keeping requirements, planning, or budgeting. As noted in Section F.2.1, the reporting requirements will be reviewed after four years.

F.2 REFERENCES

1. 44 F.R., May 29, 1979. pg. 30996-Appendix A.

TABLE F-2. SUMMARY OF RESPONDENT LABOR AND COST BURDENS

Respondent	Number of sources	First year man-hours	First year dollars	Each year after first man-hours	Each year after first dollars
1	2	534	5870	368	4050
2	2	534	5870	368	4050
3	3	946	10,400	672	7390

TABLE F-3. SUMMARY OF MANHOURS NECESSARY FOR ENFORCEMENT AGENCY TO REVIEW THE REPORTING REQUIREMENTS

Type of Report	Hours/ Report	Reports/ Source	Number of Sources	Total hours
Review of Notification of Construction	2	1	7	14
Review of Notification of Anticipated Start-up	2	1	7	14
Review of Notification of Actual Initial Start-up	2	1	7	14
Review of Notification of Physical or Operational Changes	-	none expected	-	0
Review of Notification of Demonstration of the Continuous Monitoring System	2	1	7	14
Review of Continuous Monitoring Demonstration Report[a]	8	1	3	24
	8	2	4	64
Review of Excess Emission Reports[b]	2	15	7	210
	8	5	7	280
	16	1	7	112
Review of Notification of the Administrator Prior to a Performance Test[a]	2	1	3	6
	2	2	4	16
Review of Performance Tests[a]	8	1	3	24
	8	2	4	64
Total				856

[a] It is assumed that 50 percent of the sources will submit one report, and that 50 percent will submit two reports.

[b] Each source is required to submit four reoprts each year. It is assumed that three of these reports will report no excess emissions and will require 2 hours per report, and that one report will report excess emissions and will require 8 hours/report. It is also assumed that twenty percent of the reports of excess emissions will receive notices of violation. Sixteen man-hours per notice of violation are required.